Design Engineering

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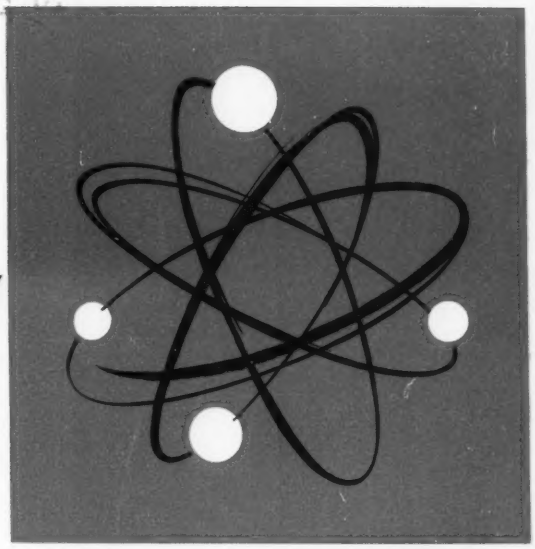

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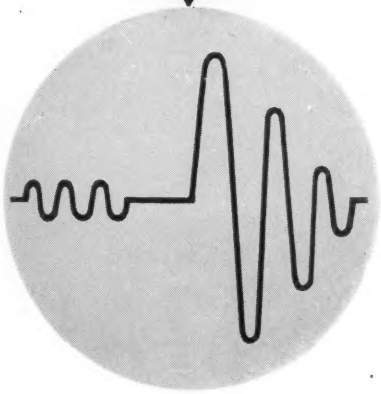

Electronic survey feature

Check up on electrical parts new and old
A new high-strength material
Mass spectrometer "fingerprints" gas

January 1956

PUBLISHED BY MACLEAN-HUNTER PUBLISHING COMPANY, LIMITED, TORONTO, CANADA

TS1
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Breaking free from the fetters of convention

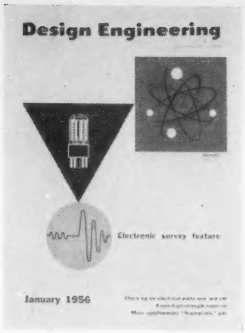
A whole new realm of possibilities in design and construction has been opened up by the development of today's lightweight metals.

No longer need the creative thinking of the modern engineer and architect be restricted to the conventional concepts imposed by the limitations of traditional materials. The unique combination of properties of aluminum alloys, for example — strength, lightness, corrosion-resistance, durability — presents a new challenge to his imagination, gives far broader scope than ever for his natural inventive and creative abilities.

No wonder more and more engineers and architects are welcoming the opportunity to break free from the deadweight of the conventional and take advantage of the many practical possibilities offered by light, long-lasting, non-rusting aluminum.

Aluminum Company of Canada, Ltd.

calgary *halifax* *montreal* *ottawa* *quebec* *toronto* *vancouver* *windsor* *winnipeg*



Design Engineering

VOL. 2 JANUARY 1956 NO. 1

This month's cover

Storm warning-like cover of this issue captures electronic activities in three specific phases. Square contains diagrammatic theory of orbital electrons; tube silhouetted in triangle is vital component in the life-line of any electronic product; and oscillogram with its hills and dales in the circle is familiar reading matter on face of the oscillograph which visibly measures sonic impulses.

Design Engineering

MEMBER

CCAB

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1945 **WATCHFUL PEACE** 1955

The constant Peace and Serenity experienced throughout the vast reaches of our colourful land have not been disturbed in a decade that won for Canada expanded engineering resources and skills.

To help maintain that status, Avro Aircraft accepted the engineering and manufacturing responsibility of providing Canada with its first twin-jet military aircraft . . . a night and day, all-weather, long-range interceptor, unlike anything then in production in the world.

The responsibility has been fulfilled. Canada's Royal Canadian Air Force has been equipped with the Avro CF-100 in multi-squadron strength. Improvements and refinements maintain its rating as one of the most effective interceptors of this type in the world. And in 1956, CF-100's will start augmenting RCAF NATO squadrons in Europe.

As Canada's second decade of jetpowered aeronautical achievement gets under way, Avro Aircraft is undertaking the design and development of a new supersonic, all-weather interceptor, which will maintain Canada's leadership in producing this type of aircraft.

It's been a decade of progress in Canadian Aviation . . . contributing to a decade of Peace that gave Canada a worthy place in world aviation.

AVRO AIRCRAFT LIMITED MALTON, CANADA

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Editorial correspondents in: The United Kingdom, the United States, Germany, France and Italy.

The February issue of **Design Engineering** will carry strong feature articles written by contributors no less experienced than those featured this month.

Glass will be the subject of our lead feature, a full review of its uses.

Practical applications of The Heat Treatment of Aluminum will be another valuable feature.

And a new approach to design in an Electric Motor for an oil burner will be reported.

Special Artwork

Editorial layouts designed by art consultant **Desmond English.**

Inside

Dutton

Birtle, Manitoba was the mid-West community where Ian R. Dutton, co-writer of the Electronic Survey—lead feature this issue—was born. Completing high school during the war, he joined the Canadian Army where he became first a radar technician, then instructor. At war's end he came to Toronto University and graduated with an electrical engineering degree. Engineer Dutton was then hired by the Canadian General Electric Co., as supervisor of technical publications in the electronics department. He is now with the advertising and sales promotion division of J. A. Wilson Lighting and Display. The photo at left is a self-portrait taken in his well-equipped studio.

Eggleton

Although accounting was the original course that Larry Eggleton had in mind as he burned the midnight oil at St. Joseph de la Salle in London, England in 1937, fate and vocational guidance were at odds with the ominous events at Munich and finally Poland and the Lowlands. The RAF then—and suave Eggleton found himself bounded by the fascinating realm of electronics. In the service his travels extended to India and Malaya, with further itineraries to South America and the West Indies in civilian life following his discharge in 1946. He is broadly versed in electronics, having spent several years with Aviation Electric Ltd., and further employment with C.G.E., where he first worked under supervisor Dutton and then filled the vacancy when he left. Writer Eggleton is now living in Montreal where he says his main hobby concerns the arranging of furniture in his new apartment.

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Reports

News in brief from the world's producers

MONTREAL — Each spring there is a gigantic auction of talent as graduates from colleges across Canada are wooed by companies large and small. Indeed, as most engineering graduates parade to convocation exercises they are already placed in their career.

This year the **Canadian National Railways** has put in a bid for the college-acquired skills of the engineer graduate, putting a brochure in his hands outlining the advantages of railroad engineering. But instead of governing the throttle, the engineer in this case although he may be equally transient in his career, will work to develop and produce the stationary and rolling stock of the system.

The talent searching publication makes it clear to the undergraduate that experience with the railway during summer vacations is a boon to the possibility of permanent employment.

The engineering department of the company hires civil, electrical and mechanical engineers annually. Although there is no design department as such in the CNR, there are engineering and research development divisions who work in liaison with the design facilities of companies who supply both stationary and rolling stock to the railway.

Graduates with above average ability are often hired at system headquarters in Montreal where they study the economic effects of converting from steam to diesel locomotives. Their studies involve researching of new equipment such as the new type air-conditioning system for passenger cars being pursued at the present time.

Engineers in the materials and testing branch work on specifications and standards for the components and materials in railway operation which are rigidly governed by the American Association of Railroads. This strict conforming to U. S. standards is dictated in part by the constant exchange of Canadian and American freight and passenger cars. The possibility of adapting newly developed materials for railway use is investigated also.

In the communications department of the company, graduate engineers are concerned with the development and maintainance of standards, construction and repairing of open wire lines, cable leading, balancing, testing and the design and installation of gas pressure systems.

The radio systems of the railway are kept in service by another group of engineers who conduct propagation tests, develop estimates, and make initial layouts. Today the CNR uses frequency modulated VHF, microwave relay, high frequency radio telephone, and mobile radio installed on locomotives. Equipment engineers set standards for layout and installation of this equipment.

In the mechanical department, the graduate engineer is involved in the design of new cars and equipment, ensuring that lighting, air conditioning, wheels and brakes are up to the railway standard.

What course of training will the graduate expect to follow with the railway? This query paramount in the minds of young engineers along with the question of salary, promotion, and opportunities has not been parried by railway officials.

By offering a flexible program of study in which the engineer will spend about six months in each department, he gains not only a broad picture of company operations and railroading in general, but also ferrets out the job to which he is best suited in the complex operations of the national system.

• • •

VANCOUVER — Decentralization and autonomy, a concept of many large scale industries today has been adopted by **Canadian Aviation Electronics Limited.**

The company has started construction on a 16,000 sq. ft. plant here which is scheduled for completion by late Spring this year. CAE with headquarters in Montreal has five strategically placed plants coast to coast.

"We hope to closely follow the demands of Canada's regional markets by decentralization," explained president and managing director, K. R. Patrick, O.B.E.

Managing the new plant will be David Manders, O.B.E., a science graduate of the University of British Columbia and former B. C. representative on the National Research Council.

• • •

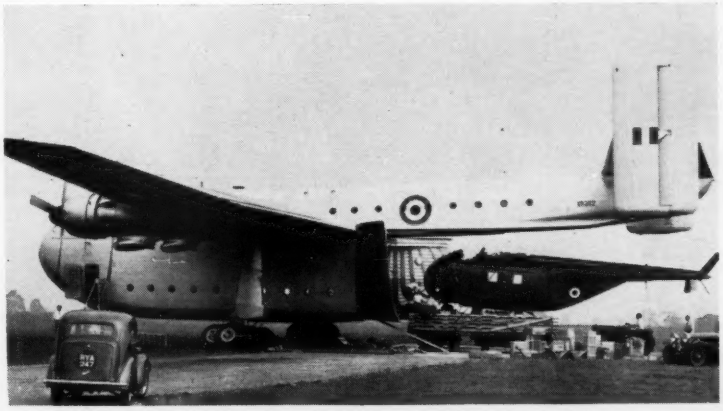
OSHAWA — The Beverley Blackburn Tanker, a gigantic air freighter with a 162 ft. wingspan has been devised here by **Field Aviation Company Limited** jointly with **Blackburn and General Aircraft,** the English manufacturer. After being flown to Canada by an RCAF crew for winterization trials at Edmonton the freighter made its North American debut in Ottawa mid-December.

Design of the 99 ft. long aircraft makes it fully adaptable for supplying all types of fuel and other items to Arctic stations on the DEW-line, open by sea only one month of the year. It can carry a maximum payload of 22 tons in the low-slung boxlike hold that measures 40 ft. by 10 ft. by 10 ft. Height of the aircraft is 33 ft. The over-all measurements allow the freighter to accommodate vehicles as large as a Greyhound bus that may enter through enormous clam-shell type doors at the back of the built-in floorboard ramp.

Ushering in a new era of air freight, the Beverley despite its size and weight loaded can get airborne in 1,000 yds. from a grass field: It will land in even less distance.

With a maximum load the Beverley can travel 1,000 miles in still air. It has a 1,400 mile range with a 16 ton load.

The features incorporated in the design of the freighter are similar to the requirements noted by the Rt. Hon. C. D. Howe, Minister of Defense Production, when he spoke of the need for such an aircraft recently at the Canadian Aeronautical Institute in Ottawa.



The Blackburn Beverley freighter commodious transport giant

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CENTRIFUGALLY CAST STAINLESS STEEL

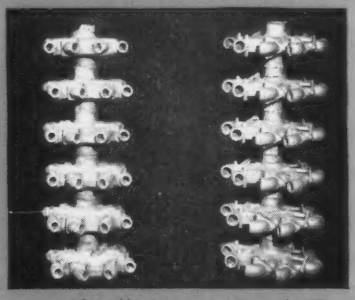
YIELDS A SUPERIOR CASTING! OFFERS ADDED ECONOMIES!

In the production of cylindrical shapes, and for small castings of irregular shape, the *Centrifugal Casting Method* yields a quality product much superior to that produced as a static casting.

And Shawinigan PERMA-SPUN offers significant economies over drawn tubing. Even on small quantities of any specific analysis the cost is low, and on large runs permanent molds can be used permitting a thinner wall and less machining allowance.

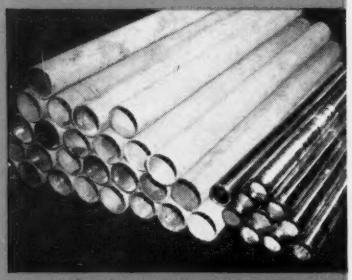
Centrifugal Force ensures complete freedom from non-metallic inclusions and shrinkage and creates a dense, fine-grained casting with enhanced physical properties.

Centrifugally cast CF10M pipe for sulfite acid circulation systems.



Centrifugally cast stacks of CF8 fittings (as cast condition).

Centrifugally cast HU retorts for magnesium production.



Centrifugally cast radiant tubes and rolls for heat treating furnace — cast in permanent molds.

Illustrated are a few of the many applications of *PERMA-SPUN* corrosion and heat-resistant stainless steel. Consider the possibility of saving money in your operations with "Shawinigan" *PERMA-SPUN* centrifugally cast Stainless Steel!

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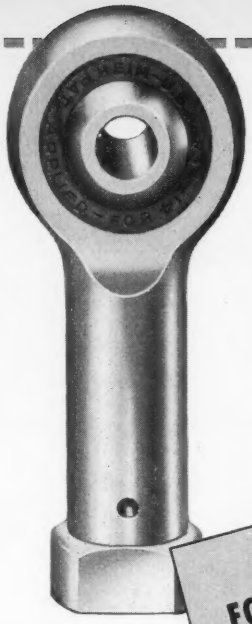
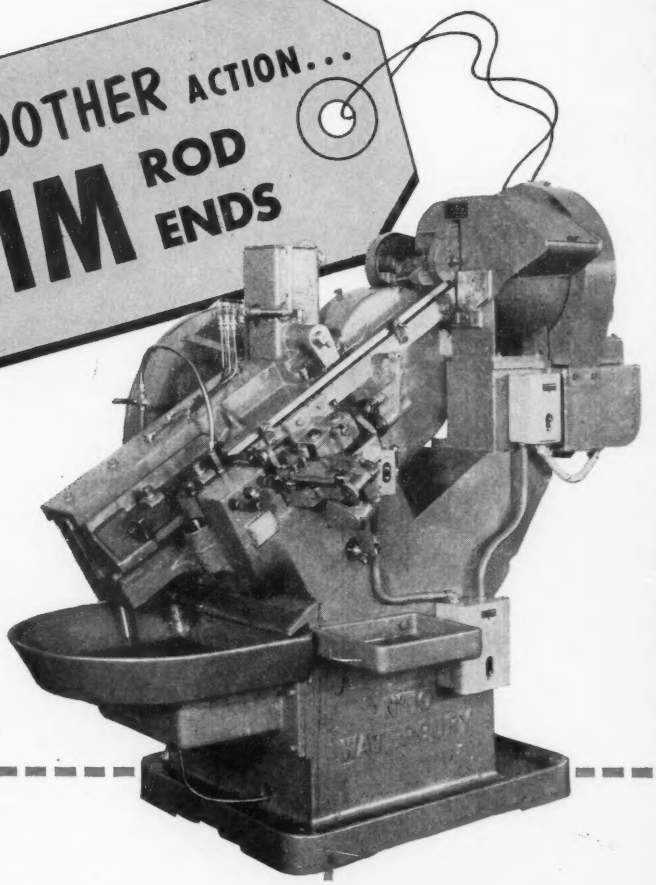


For the transmission of force and motion from one machine component to another, HEIM UNIBAL SPHERICAL BEARING ROD ENDS are more dependable, more efficient, and eliminate the necessity for specially machined components. Misalignment of stud or shaft is corrected in all directions.

FOR SMOOTHER ACTION...
HEIM ROD ENDS



Heim Unibal Spherical Bearing Rod Ends are used on Waterbury-Farrel Automatic Screw Thread Rolling Machines. The chief advantages of the process of thread rolling are greater uniformity, no waste of metal, and increased production at less cost, plus accuracy and strength.

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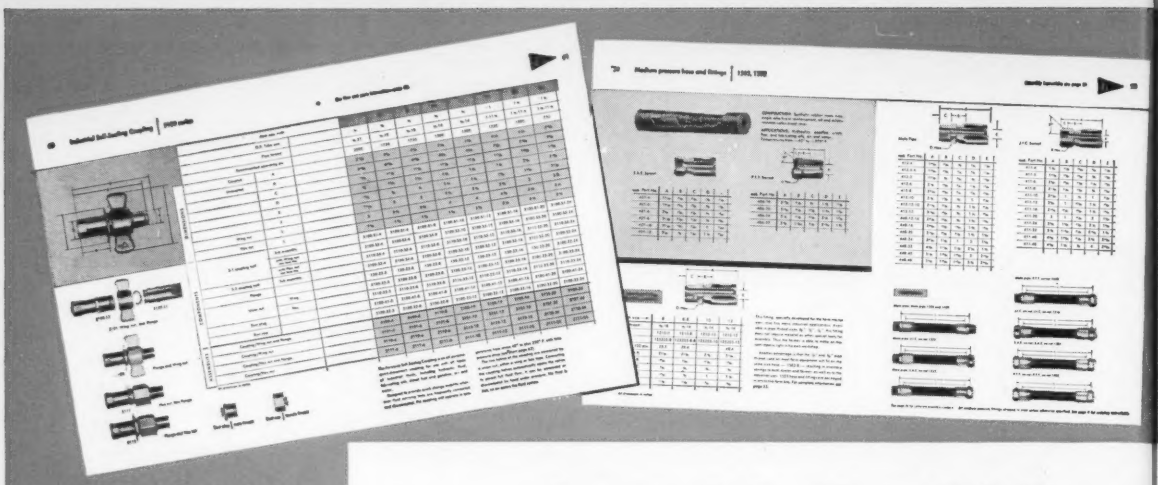
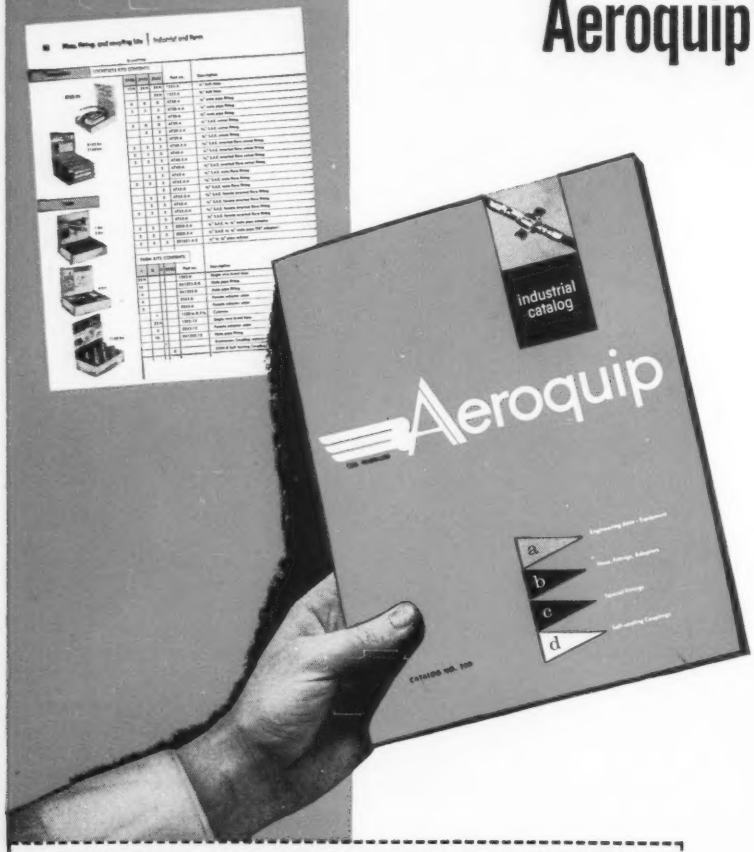


Aeroquip's New 64-Page Ind



EACH SECTION CONTAINS HELPFUL INFORMATION!

SECTION A contains the following engineering data and equipment:

- products and services
- ordering instructions
- hose fluid reference chart
- planning of hose installations
- bend radius vs. operating pressures
- vacuum data
- thread interchange data
- bulkhead hole size data
- hand tools
- support clamps
- hose cover stripping tool
- hose cut-off machine
- hose assembly machines
- hydrauliscope

SECTION B contains the following hose, fittings and adapters:

- low, medium, high and very high pressure hose lines
- air brake hose
- coal shooting hose
- grease hose
- ammonia hose
- LPG hose
- steam hose
- trichlorethylene hose
- diesel fuel hose
- Freon hose
- hot water hose
- low temperature hose
- electrically non-conductive hose
- fire-resistant hose
- S.A.E., J.I.C., Parker, and Union adapters
- assembly combinations chart
- assembly instructions
- kits

SECTION C contains the following special fittings:

- flange type, split flange type and Globe Seal fittings.

SECTION D contains the following Self-Sealing Couplings:

- industrial and farm Self-Sealing Couplings, and farm Breakaway Coupling.

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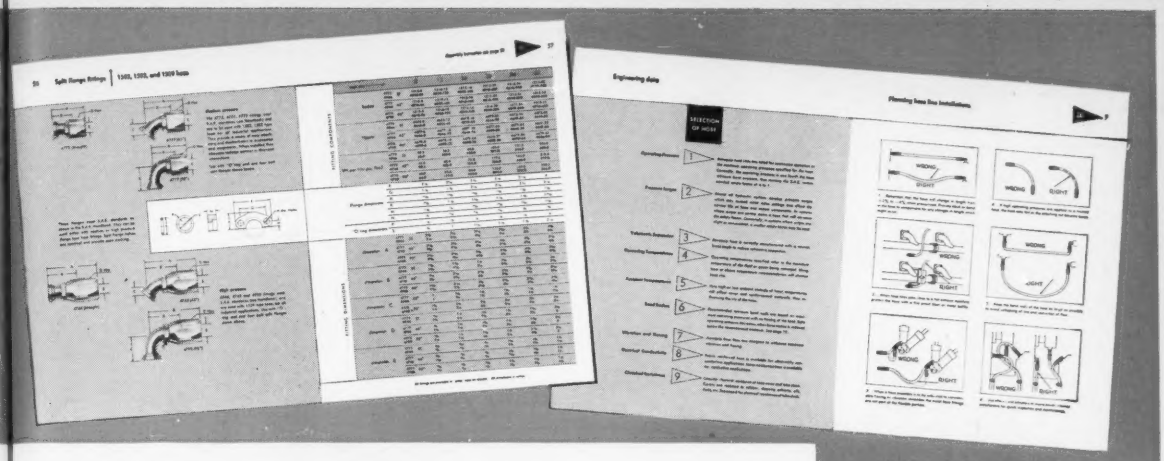

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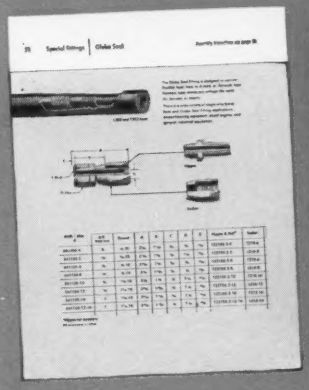

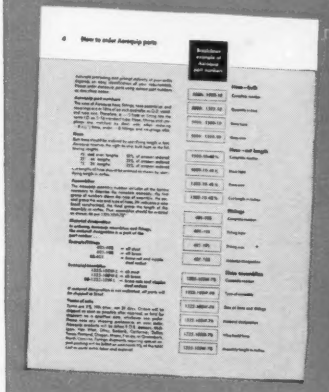

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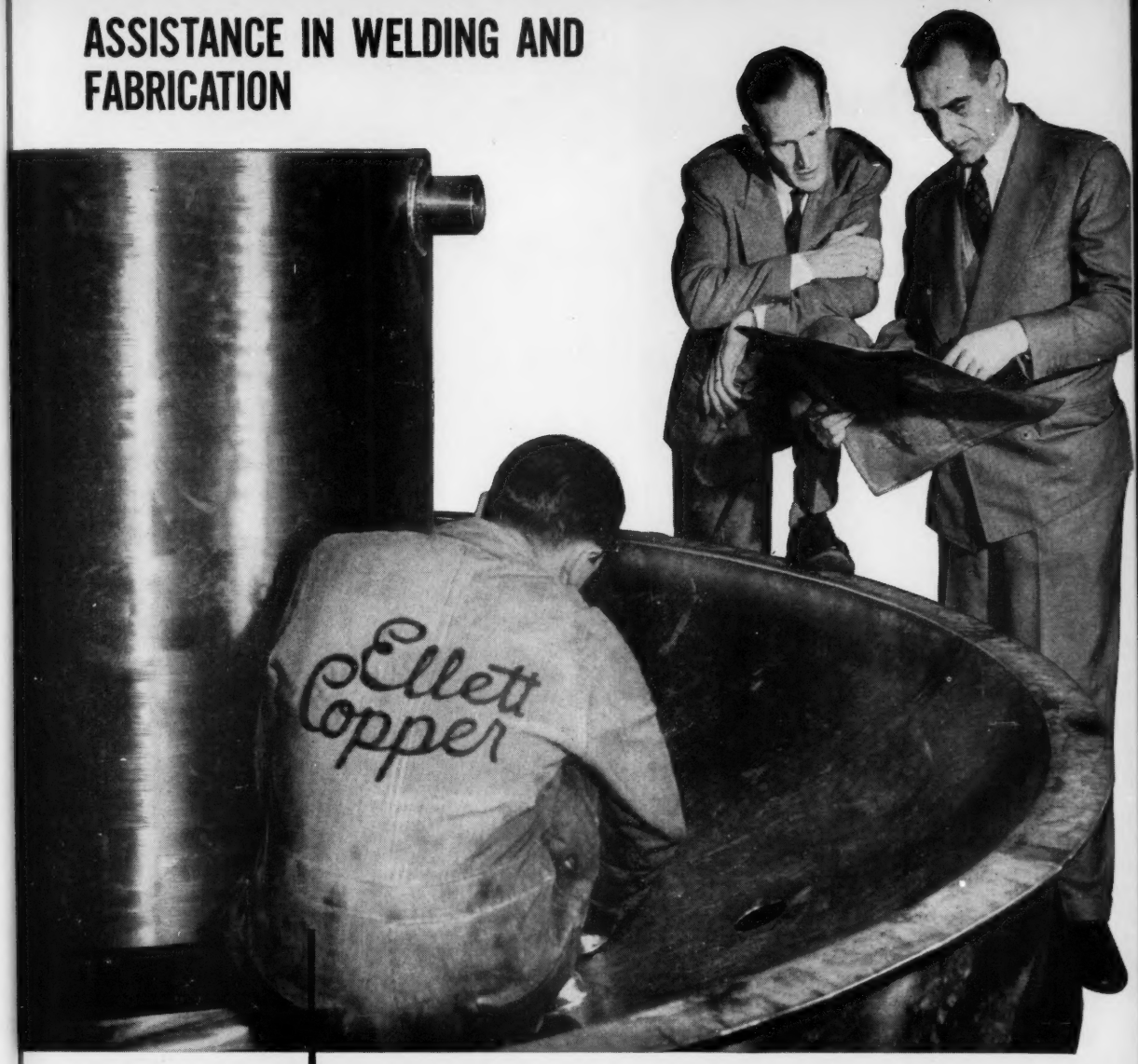
ASSISTANCE IN WELDING AND FABRICATION



CO Research Engineer at an on-the-job
ference in the plant of Ellett Copper
Brass Co., Ltd., Vancouver, where work
ogresses on a nickel-containing stainless
el bottom for a brew kettle.

INCO can be of service* to you

The aid in welding and fabrication given on the job illustrated above is typical of the personal assistance available to Canadian industry through INCO service. Through this service, INCO puts its facilities, personnel and experience to helping solve the many metal problems which occur in the never ending search for better products. Take advantage of the wide range of practical experience and background information available through INCO Research Engineers . . . if you have a metals problem with any of *your* products, let INCO be of service to you.

**Information involving corrosion, fabrication, foundry problems, high and low temperature service and metals selection.*

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DEVELOPMENT AND RESEARCH DIVISION

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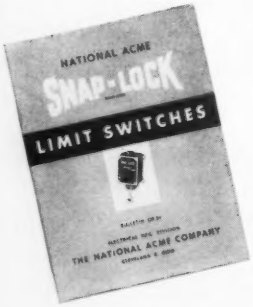
here's the limit switch that spells electrical control dependability in any language



Send for Bulletin EM-51 which shows various types of Snap-Lock Limit Switches available, design features, specifications, wiring diagrams, ordering data — and other National Acme electrical components and controls.

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Mechanical simplicity and ruggedness are the reasons why Snap-Locks have proven an outstanding success in thousands of heavy duty equipment installations. The record shows that in many such cases, they have stood up under more than 15,000,000 contacts.

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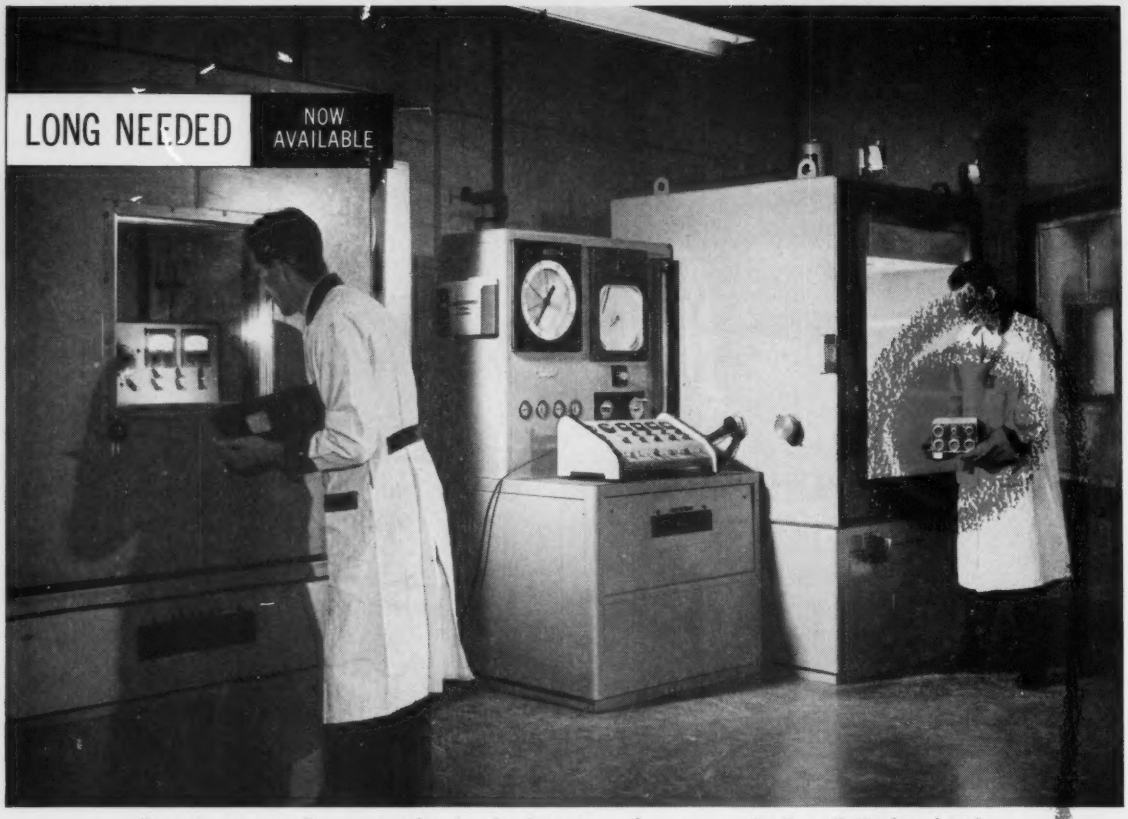

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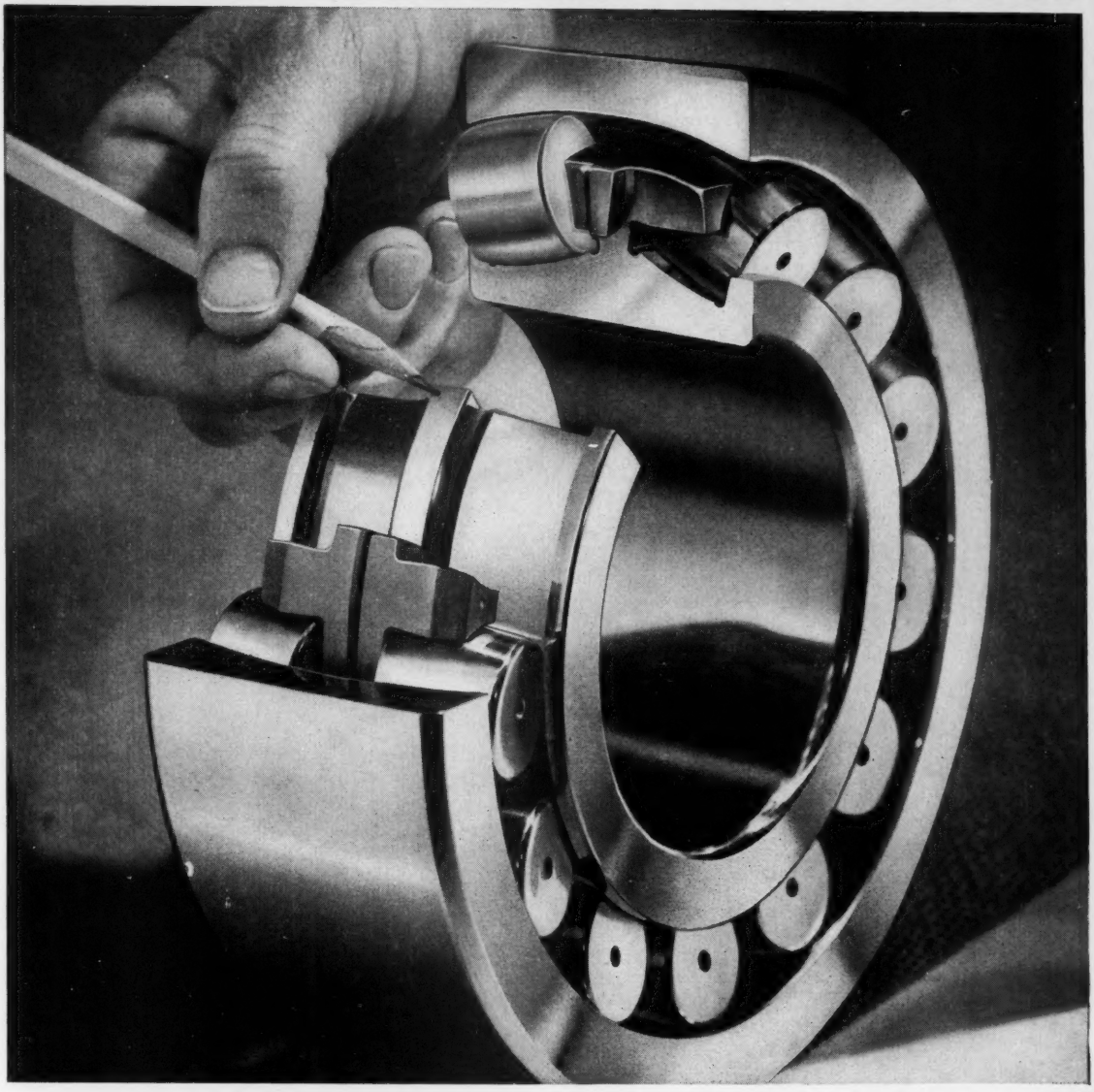

"This flange guides the rollers to peak performance!"

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For long, low-maintenance service in heavy-duty applications, order TORRINGTON Spherical Roller Bearings. They're available from stock with either straight or tapered bore, for shaft or adapter mounting.

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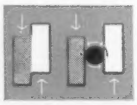
Spherical Roller • Tapered Roller • Cylindrical Roller
Needle • Ball • Needle Rollers

Here's a NEW, FAR BETTER ACTUATION METHOD!

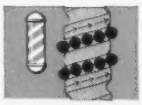
Saginaw ball/bearing Screws assure precision positioning with minimum power, size and cost

EXCLUSIVE FAIL-SAFE MULTIPLE CIRCUITS
If one circuit should fail, the rest will function without interruption, sharing the load between them. In critical applications this exclusive feature has no equal.

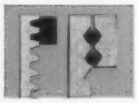
WHAT IT IS AND HOW IT WORKS



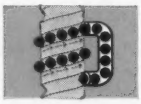
Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



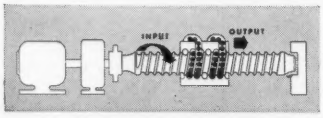
the *Safety ball/bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

TREMENDOUS ADVANTAGES FOR MACHINE DESIGNERS

Conventional Acme screw's efficiency is less than 25%; *Safety ball/bearing Screw's* ranges from 90 to 95%! Combined with electric, hydraulic or pneumatic power source, it forms an actuator with unprecedented capabilities, that:



SAVES POWER—*Safety b/b Screw* requires only 1/3 as much torque for same lineal output as conventional Acme screw. With far lower static break-away, it operates with much less starting and driving power. This permits the use of much smaller motors with less load on the electrical system.

SAVES SPACE—Permits use of smaller motors and gear boxes; eliminates pumps, accumulators, piping, etc.

ASSURES POSITIVE POSITIONING—permits precision control within thousandths of an inch, plus perfect synchronization.

INCREASES DEPENDABILITY—offers longer life and added security of *exclusive multiple circuits*, plus greatly decreased dirt sensitivity of special "Gothic arch"-shaped races.

REDUCES PART AND INSTALLATION COSTS—savings in weight, motor size, power and auxiliary equipment cut cost, too.

UNITS HAVE BEEN BUILT FROM 1½ INCHES TO 39½ FEET LONG

Every *Safety b/b Screw* is individually engineered for its particular application. Our engineers are eager to help solve your actuator problems *now*.

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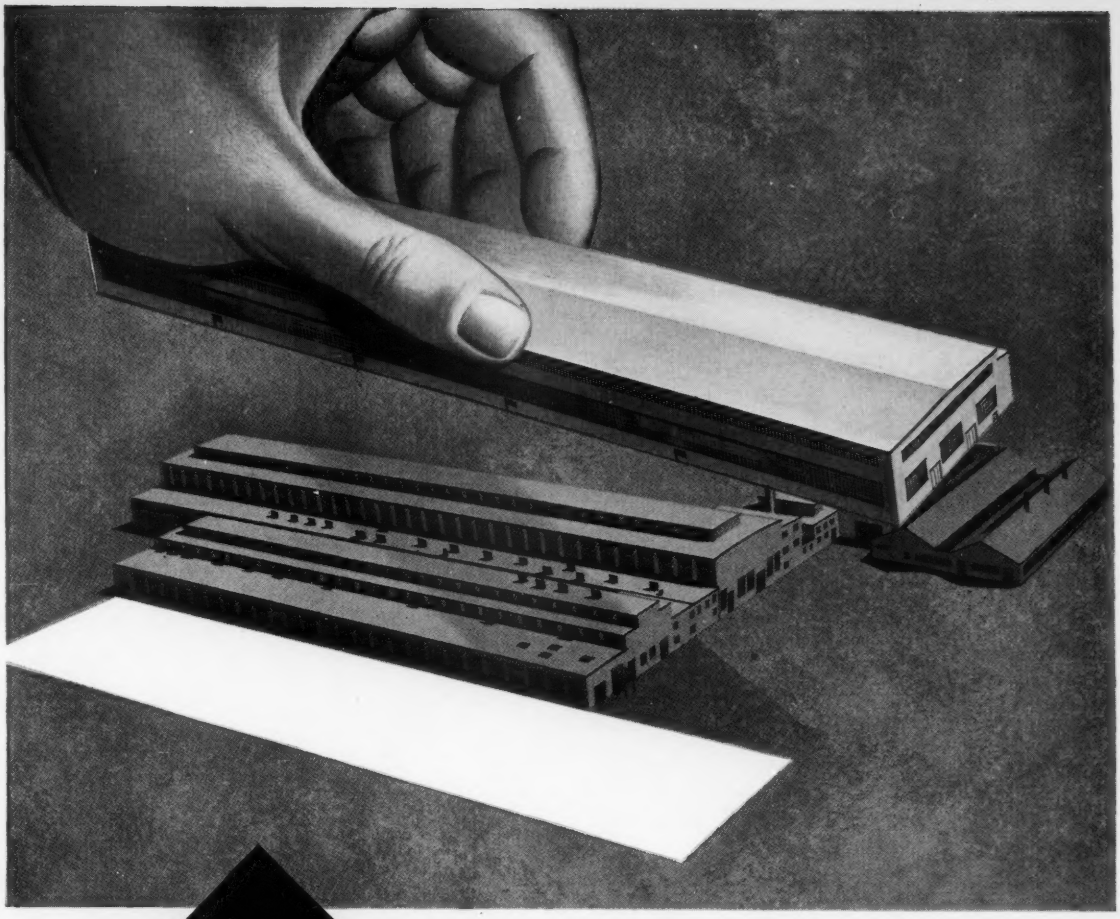
Safety ball/bearing Screw by Saginaw



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Growing with Canada

Noranda Copper and Brass Limited is proud to announce an important addition to its modern plant at Montreal East. A new tube mill is now under construction adjacent to the present mills.

Canada's industrial growth has created an unprecedented demand for high-quality copper and copper-alloy tubing. The new Noranda mill is designed not only to meet today's pressing requirements . . . it has also been planned to anticipate the future needs of both Canadian and world markets.

The new building will increase present manufacturing area by more than 50%. Equipment will include the most up-to-date machines and instruments for improved product range and quality control.

Noranda Copper and Brass Limited

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Wear is a problem wherever two surfaces slide or roll against each other. Parco Lubrite, one of the Parker line of surface treatments for metals, *retards* wear on iron and steel.

Parco Lubrite converts the surface of metal parts to a non-metallic phosphate coating that is oil absorbent, holding lubricant even under high unit pressures. In initial operation the Parco Lubrite coating prevents metal-to-metal contact, and break-in is quick, easy and smooth, without galling or scoring.

Parco Lubrite treated parts can be expected to have longer service life, too. You will want to know just how Parco Lubrite can contribute to the performance of the friction parts in your product. **Write today for full information.**

*Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U. S. Pat. Off.

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- FARM IMPLEMENT CASTINGS
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Crankshaft for high pressure power pump cast in ductile iron.

...typical properties...

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ANNEALED	60,000 p.s.i. to 75,000 p.s.i.	45,000 p.s.i. to 60,000 p.s.i.	10-20%	140-180
HEAT TREATED	80,000 p.s.i. to 160,000 p.s.i.	65,000 p.s.i. to 150,000 p.s.i.	1-15%	160-340

...and when to specify it...

1. As a replacement for conventional cast iron, where greater strength or resistance to impact is needed.
2. In redesigning, where higher strength results in less weight — hence lower cost.
3. In place of large malleable iron castings which can be difficult and costly to produce.
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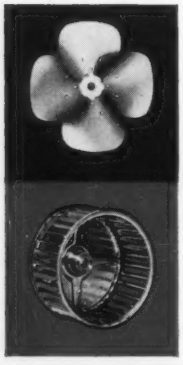
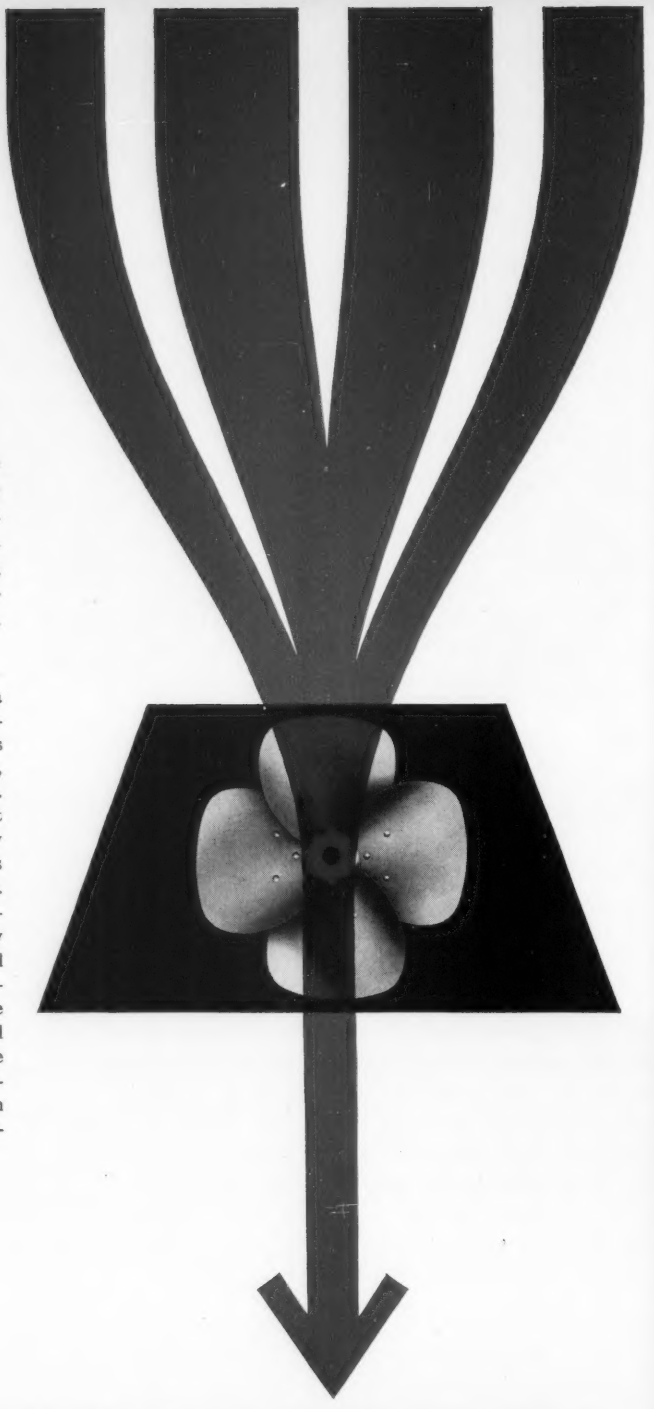
Maximum Air Delivery in Pressure Applications

...that's what you get with the Torrington "P Series" fan blade

Designed for a wide variety of pressure applications, the "P Series" fan blades turns in a top performance in many leading makes and models of modern air-moving equipment. Large blade area in relation to diameter gives maximum air delivery. Available in 10"–11"–12"–13"–14"–16"–18" diameters.

The "P Series" fan blade represents only a small portion of the unusually broad variety of air-impellers which Torrington is currently equipped to produce for heating, ventilating and air-conditioning equipment. This product range, plus Torrington's great capacity, can provide... quickly and at low cost... the fan blade or blower wheel that's best suited to your air-moving requirements. Torrington also maintains a complete research testing service for assistance on any design problem relating to air flow, sound and vibration. This service is always available to you and can be of particular value in the early stages of product design and development. No one has more experience in the design and production of air-impellers than Torrington. Nowhere else can your dollar buy so much in terms of product quality and customer service.





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VIP's

Important people who are in the news

"THERE IS A great disparity in mechanical engineering procedure between the U. K. and Canada," observes **Bernard Eyden,** newly appointed chief mechanical engineer of the Canadian Inspection and Testing Co. Ltd. "Mechanical engineers in this country design factories and manufacture products with a definite purpose in mind, but the U. K. still clings in some degree to the old idea of craftsmanship — making in many instances a stronger or better product than is necessary."

In his eight-year residence in Canada the dark-haired expressive engineer has appraised the merits and shortcomings of both countries in the engineering field.

His reactions conditioned by several years spent as Technical Assistant to the Works Manager of the Associated

BERNARD EYDEN
"How long does it need to last?"

Equipment Co. Ltd., of London in prewar England do not necessarily submerge the idea of a superior product but sobers its value on a highly competitive market where mass production is a must.

"The question we should ask ourselves is—'how long does it need to last?'—and in many cases the answer given is less by far than the British manufacturer's," he added.

A career that began with his graduation from Southall Technical College in London took engineer Eyden from buses at Associated Equipment to bulldozers at Canadian-Brazilian Services where he worked on preliminary design, also the procurement and inspection of equipment for the parent company, Brazilian Traction, Light and Power Co. Ltd. Most of his work there involved the new hydroelectric developments in Brazil. Although he never left Toronto, he was directly responsible for many phases of construction at Ulo Pecanha and Cubato.

Before he joined Canadian-Brazilian Services, much-traveled Eyden spent five years in the Royal Electrical and Mechanical Engineers where at war's end he was in command of a Light Anti-Aircraft Workshop.

Landing in North Africa earlier he participated in the Salerno invasion and pressed north to Naples with the British 46th Infantry in company with the Canadian 1st Division.

Today at 36 he is in charge of inspection and testing projects for such large companies as General Electric, Westinghouse and Algoma Steel. His staff, visually and by gamma and X-ray cover many types of inspection assignments. Some last days; others will take years.

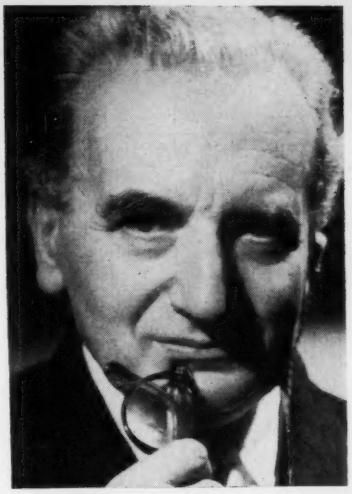
Engineer Eyden is married and lives in suburban Toronto with his wife Constance and two children. His hobbies include photography, and gardening, which he confides, is self imposed by necessity rather than choice.

• • •

THE SENIOR scientific adviser on aeronautics to NATO and the United States Air Force, **Dr. Theodore von Karman** is a director of the newly-formed Gruen Precision Laboratories Inc. He will participate actively as chief of the planning board in the new company, a subsidiary of Gruen Watch Co., which will engineer and develop precision products for national defense and industry.

Credited with exercising the greatest influence in the development of high speed aircraft in the U. S., middle-aged scientist von Karman was awarded the Wright Brothers Memorial Trophy in 1954 for his contributions to aviation.

Building one of the world's outstanding aeronautical research centres as director of the Guggenheim Aeronautical Laboratories at the California Institute of Technology, Dr. von Karman earlier undertook leadership of the Army Air Force's first jet propulsion and rocket motor program in 1938. He proposed to the Ordnance Department of the Army prior to World War II that supersonic wind tunnels be used in ballistics.



DR. THEODORE VON KARMAN
Jet and rocket pioneer

His proposals led to design and operation of the famous ballistics wind tunnel at the Aberdeen Proving Grounds. In 1944, Dr. von Karman was named director of the site's scientific group and a special consultant to General Arnold, wartime chief of the USAF.

• • •

THE PROVINCIALLY owned Saskatchewan Power Corporation has a new general manager. He is **David Cass-Beggs,** former technical consultant for SPC who first came to Canada aboard the ill-fated Athenia in 1939 when the liner was torpedoed by a German submarine.

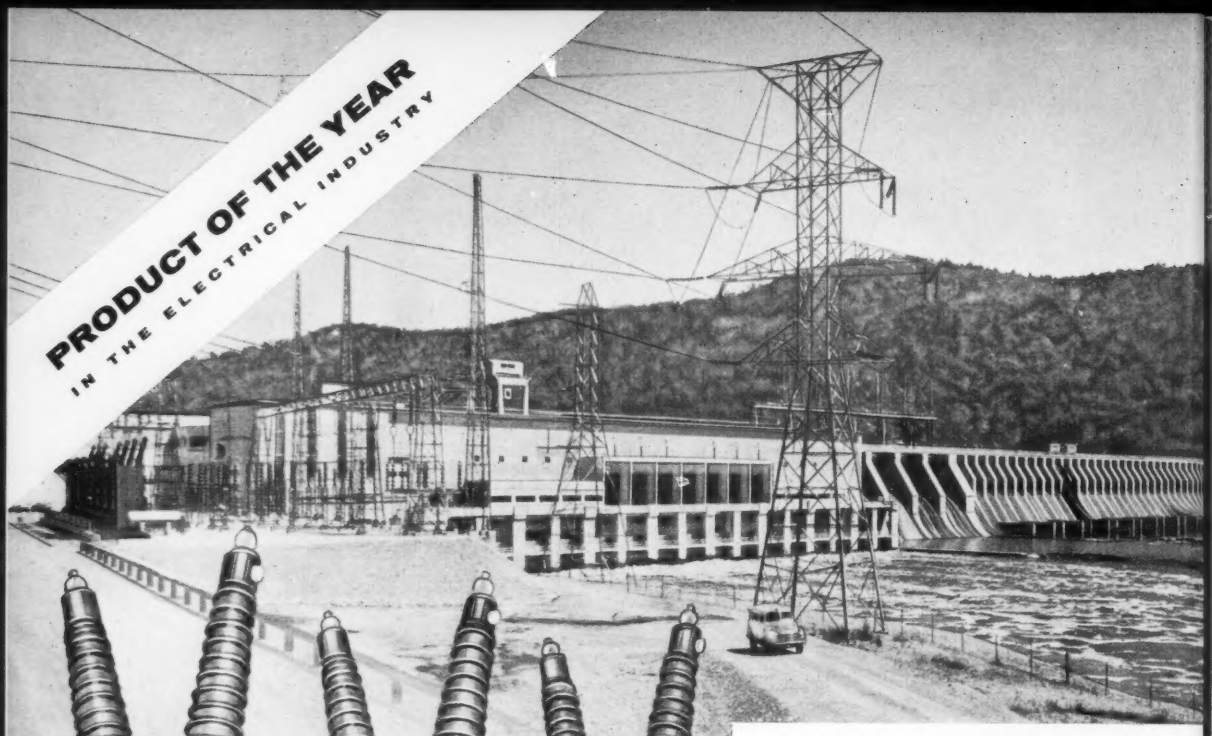
Born and educated in England, he joined the faculty of Toronto University as an associate professor of electrical engineering. Two years ago he returned to the U. K. where he was put in charge of electrical engineering at University College, Swansea, Wales. He resigned tht post last spring to accept the Saskatchewan job.

Soft-spoken but persuasive the greying general manager outlined the goals of his new appointment: "We will have to lay out adequate expansion plans for the corporation's rapidly expanding natural gas and electrical systems in Saskatchewan," he declared.

"No place in North America has a similar situation where the phenomenal demand has doubled in four years," he reflected. "We must plan to meet that demand."

Responsible for developing an automatic accelerator for use by the RCAF, his device was later used by all allied air forces.

A family man with three children, he regrets that they cannot join him in Regina until later.



Proves Again that Westinghouse has the Creative Engineers

PHOTOGRAPH OF A TYPICAL GENERATI
COURTESY ONTARIO HYDR

Harvey McKeough

Carl Smith

Brilliant engineering conceived and developed this electrical "Product of the Year"—the JETAIRE Circuit Breaker.

Power from mighty generating stations like the above does much of our work today. Transmission of the electricity from such remote waterfalls to our cities is by high voltage power lines.

The Westinghouse JETAIRE Circuit Breaker's function is to switch power as required, and to protect the generators and the power lines at all times. Uncontrolled, the flame produced by opening a high voltage line would be comparable to the blast from a military flame thrower.

But, the Westinghouse JETAIRE breaker, "Product of the Year", extinguishes it as easily and faster than you can puff out a match, by releasing a single blast of air that draws the arc, extinguishes the flame and opens the circuit.

Engineering triumphs like the JETAIRE, a radically new design of Circuit Breaker, demonstrate Canadian manufacturers' capacity to invent, to design, to develop, and to manufacture. At Westinghouse creative engineering is a tradition that thrives because Westinghouse attracts young men of creative calibre like Harvey McKeough and Carl Smith, brilliant Canadian engineers who developed the JETAIRE Circuit Breaker.

YOUR ELECTRICAL NEEDS ARE ALWAYS OUR CONCERN AT WESTINGHOUSE

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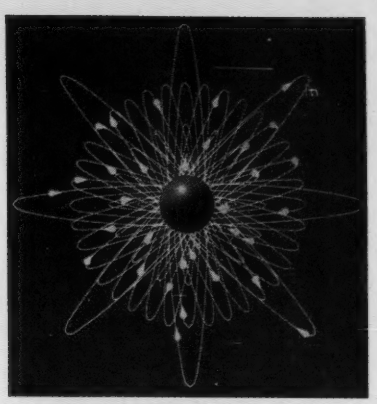
Design Engineering



IAN DUTTON & LARRY EGGLETON OFFER AN:

Electronic products review

to bring your knowledge up to date

FEW INDUSTRIAL children have grown as quickly, or as large, as electrical engineering. From it has come the wonderful world of electronics, now multi-million dollar business, which affects every person and every other industry.

This review, specially prepared for DESIGN ENGINEERING, discusses the changes that have taken place due, mostly, to the trends toward automation and miniaturization.

It is interesting that electronic components have become steadily smaller. This has happened despite increasing efficiency and more complex design. Designers have also managed to build into recent components a simpler construction, with better reliability. And parts have been standardized to reduce costs.

The articles go freely through the more widely used electronic products, looking back to earlier days where development seems of special interest. They are intended to bring readers up to date on a fast changing subject and to fill in some of those gaps that every engineer is bound to have in these specialist days.

The components have been broken up into a series of headings. Each is defined, discussed and illustrated.

The editors suggest that readers keep this issue of DESIGN ENGINEERING close at hand so that the following 16 pages can become a lasting reference.

THE PRODUCTS LISTED BY THE HEADINGS BELOW ARE DISCUSSED ON THE NEXT 16 PAGES ▶

RESISTORS 1
CAPACITORS 2
TRANSFORMERS & INDUCTORS 3
TUBES 4
METERS & INDICATING DEVICES 5
MOTORS, GENERATORS & SELSYNS 6
MICROPHONES, PICKUPS & SPEAKERS 7
WIRES & PRINTED CIRCUITS 8
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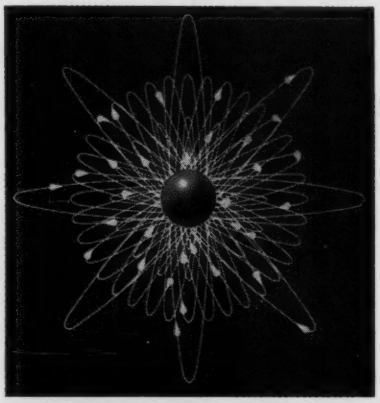
FUSES & CIRCUIT BREAKERS 13



1: Resistors

ONE HUNDRED and thirty years ago, the German scientist Ohm began to study the relationship of current, voltage and resistance. He found that E=IR — the famous Ohm's law which has been the bane of so many schoolboys since. His work has been of immense importance in the study of electronics. Ohm was honored for it when his name was adopted as the term for the unit of resistance.

The idea of resistance is quite simple. Any material through which you try to pass a current will resist the flow, and resistors are made up from some selected materials as small cylindrical devices painted with bright identification bands.

Unfortunately a closer look shows that it is less simple than it seems. Resistance is not a constant property, nor is it possible to make a pure resistor without some small amount of capacitance or inductance. Every material, metallic or non-metallic resists current flow; those with low resistance are classed as conductors (metals in general) while those with high resistance are classed as insulators. It is in between that we have the family of resistors.

The prime functions of the resistors used in electronic equipment are to limit the current flow or to create a source of voltage. In the first case where the voltage source is constant, or at least has a maximum value, the resistor can be used to limit the maximum current flow through some other device. For this, the resistor is usually placed in series with the device. When used as a voltage "source," current is passed through the resistor and the resulting voltage difference across the resistor is used.

An example of this is the coupling resistor used to pass signal voltage from one stage to the next in a radio.

With some materials the resistance will increase as the temperature goes up; with others the opposite will occur. Experiments at very low temperatures (near absolute zero) have made super conductors out of materials that we ordinarily think of as insulators. Humidity and high signal frequency also affect the behavior of resistors (as well as conductors and insulators) and so add to the design engineer's problems.

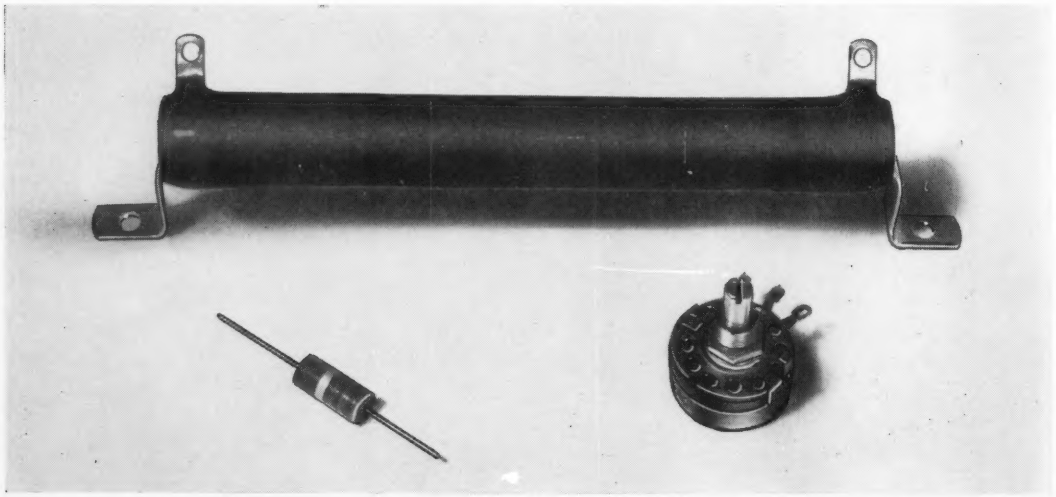
Let us look at what engineers have done about all this. Fixed value resistors are made from resistance wire or carbon. Resistance wire types are made by winding the wire around a ceramic or glass body. Carbon types are made either by depositing carbon on a body or by mixing the carbon with a bonding material and molding the resistor under pressure and heat.

Composition resistors are available in values ranging from about 2 Ohms to 22 megohms in tolerances of 5, 10, or 20%; closer tolerance can be had if resistors are carefully picked. They can handle only small amounts of power and are normally rated at ½, or 1, or 2 watts. Wire wound resistors can be made to very close tolerances — from about 15 megohms down to a fraction of an ohm (at 1 watt rating) for use in meters and test equipment. They can also be made in high power (several hundred watts) versions — usually with resistance ranging below 100,000 ohms.

It is worth mentioning that heating elements on electric stoves and in water heaters are just wire resistors rated at low resistance and high power.

Variable resistors also make use of resistance wire or carbon deposited on an insulator and formed into an arc with the moving contact in the centre. Resistance and power ratings follow the same trend as the corresponding fixed resistors.

Simultaneous control of several circuits can be obtained by mounting the required number of variable resistors on a common shaft. On-off switches can also



To the rear, a wire wound power resistor; left front, a composition resistor; right front, a variable type resistor.

be added of the type you find on your radio where the switch is combined with the volume control.

Variable resistors having a rotating adjusting arm are also rated by "taper" and "torque." The taper refers to the curve plotted on a graph with percentage of rotations as the horizontal axis and percentage of total resistance as the vertical axis. Straight line and logarithmic curves are in common use — but manufacturers can produce almost any desired taper for special cases.

The torque needed to turn the variable resistance arm is seldom given a second thought by the designers of broadcast or TV receivers. Yet it becomes an important factor in the design of remotely operated potentiometers. Servo motors must be strong enough to overcome the torque to move to the correct setting. On the other hand, if the control is made with low torque as one of the prime factors, the designer may find that the contact between the moving arm and the stationary resistor is so poor as to be unreliable in use.

Machinery mixed with skill

Today's manufacturing techniques rely on the use of machinery for winding the wire resistors and for mixing, forming and coating the composition resistors. But skilled and semi-skilled labor is still needed throughout to guide the machines and carry out the constant test and inspection that promises a uniform high quality.

Resistors can be made directly as a part of a printed circuit by using a resistive ink or compound. This is done by printing a line between two conducting points. The type of ink, width, thickness and length of line gives the resistance and power rating. But, at the present time, printed wiring is used more extensively than printed circuits and the low power resistors can be used in their present form. Most of them have stiff leads extending axially from either end. These are bent at right angles to the body to fit into holes punched in the printed wiring board. Soldering completes the process.

Variable resistors can also be mounted on a printed wire board with extensions on the terminals to make connection with the printed wiring.

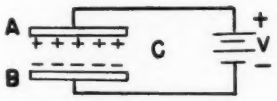
Plug-in resistors are generally used where the power rating exceeds about 2 watts. The idea of plug-in resistors goes back quite a long way. Radio manufacturers used them in the '30's enclosed in a standard metal tube envelope. Besides being very convenient to replace, they gave the consumer the impression he was buying a powerful radio with lots of tubes.

A new product now on the market is resistance tape. This has a resistive coating on one side and an adhesive coating on the other. To form a resistor of whatever value, the tape needs only to be cut off to the right length, stuck down and connected at the two ends. It is convenient, neat and inexpensive.

2: Capacitors

IT WAS in 1746 that a Dutchman, named Musschenbroek, discovered capacitance and invented the Leyden jar. Unlike Ohm, he was not honored by having his name given to the unit of capacitance. In fact nearly a century passed before a name was selected and then the word "farad," after the Englishman Faraday, was chosen.

Before discussing some capacitor types, a quick review of principles will be helpful. If you take two metal



plates (A and B in the diagram) and connect them to a battery, there will be a momentary transfer of electrons until plate A assumes a positive charge and B a negative one. The amount of charge (Q) depends on both the voltage V and the capacitance C. The formula is: Q=CV. Capacitance is a physical characteristic which is in proportion to the area of the metal plates and the distance between. It also depends on the dielectric constant of the

Capacitors: 1. Oil filled; 2. High voltage vacuum variable; 3. variable tuning-air dielectric; 4. plug-in; 5. dry electrolytic; 6. bathtub; 7. paper; 8. ceramic feed through type; 9. molded; 10. mica.

insulator (air, glass, mica, water and so on) between the plates.

The design engineer, when attempting to produce a specified capacitance must strive for minimum size and maximum working voltage at reasonable cost. The voltage, of course, is limited by the insulating qualities of the dielectric between the plates.

Variable capacitors, like those used to tune your radio to different stations, are about the only ones that still use air as the dielectric. It would be difficult and expensive to build them any other way. For use in high voltage circuits, the plates can be enclosed in an evacuated chamber to allow closer spacing of the plates without danger of arcing.

By convention, air is said to have a dielectric constant of 1.0. Other substances such as mica, glass and oil have higher dielectrics which increase capacitance as well as allowing closer spacing of the plates by forming a barrier to possible arcing. Fixed capacitors come in a range from a few micromicrofarads to several microfarads for voltages up to 50,000, or higher. Impregnated paper and mica are two popular dielectrics for low capacitance.

The paper capacitors are made by placing the paper between two pieces of metal foil and rolling them up—like a cigarette. A protective case and terminals complete the assembly. For high voltage use, the paper is impregnated with oil and the capacitor is mounted in an oil-filled metal container.

Mica capacitors are used extensively in high frequency circuits. They consist of alternate layers of thin mica and metal foil sheets. The sets of opposite polarity plates are brought out at opposite ends where they are soldered to each other, forming the two terminals. The assembly is clamped firmly together and enclosed in a molded case.

Another type of capacitor which features high capacitance at low cost and small size is the electrolytic capacitor. It consists of three main parts: The anode; the dielectric film; and the electrolyte. The anode forms one plate on the capacitor while the electrolyte (which may be liquid or paste) forms the other. They are separated by a very thin gaseous dielectric film that is formed electrochemically on the anode. For a given area of anode surface, the capacitance in microfarads is inversely proportional to the thickness of the dielectric film. And the film thickness is proportional to the voltage during electroformation of the film. So, capacitors with very low voltage ratings may be made with very high capacitance.

The d-c voltage which an electrolytic capacitor can withstand is governed by the voltage at which the original film is applied. The polarity must always be maintained the same except with some of the more recent non-polarized types.

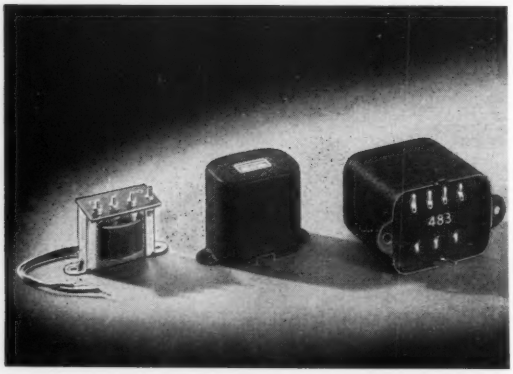
This sketch of the three common capacitors has been oversimplified. Needless to say, there are many other factors involved such as: inductive or non-inductive winding of paper capacitors, sprayed foil anodes for electrolytics, variation of capacitance with temperature and so on. But important points have been mentioned.

With the coming of precision and high frequency electronic equipment, came also the development of a new group of small, stable capacitors. Most of them are made by spraying or plating metal on ceramic, then molding them into cases. This gives capacitors that can stand shock and vibration but which are not affected by temperature and humidity changes. Trimmer capacitors, variable over a small capacity range, are made in much the same way. They lack the moisture-proof coating, but the cases are built to keep out dust which would tend to cause leakage and arcing.

The size and weight of capacitors has decreased during the past few years to cope with the restrictions imposed by complex circuits, particularly in airborne and mobile equipment. At the same time, reliability has increased, along with new features such as plug-in bases for quick assembly and replacement.

Printed circuits can quite easily incorporate capacitors. At least one manufacturer now markets a series of printed components and circuits which includes capacitors, filter networks coupling and integrating networks. These are encased in a molded body with numbered leads extending from the side.

3: Transformers & Inductors



Transformers, inductors generate opposite polarity voltage if current is started, stopped.

MOST ONE-TIME high school physics students will recall the induction coil — with its spectacular six in. spark. Although it may not have been realized at the time, a transformer was being watched at work.

A transformer has two separate coils of wire wound so that their magnetic fields are capable of affecting one another. Any change in current flowing through one coil is reflected in the other. A remarkable part of the coil's behaviour is that it seems to achieve that elusive goal of getting us something for nothing. If the number of turns of wire on the coil that has no voltage applied to it is more than those on the one charged, we shall finish up with a larger voltage than we started with. This gives us the six in. spark on the induction coil — so impressive to young eyes.

Both transformers and inductors operate on the principle that if an electric current is started or stopped whilst flowing through their windings, the appearance

(or disappearance) of the associated magnetic field will cause another voltage to be generated of opposite polarity to the original one. Many people will recall receiving a brief electric shock when testing an electric bell with a battery. Disconnecting the battery can produce a voltage in the bell coil of opposite polarity and has discharged through our fingers.

If we now imagine an alternating voltage applied to an inductor at a frequency of 60 cycles per second, we have, in effect, a disconnection of voltage every 1/60 th of a second. This means that an inductor will present a resistance to the flow of alternating current, but will allow a direct current to pass without hindrance. A good analogy of the operation of an inductor can be made by connecting a coil of copper wire to a water supply. If a continuous flow of water is allowed through the pipe very little resistance will be offered. But suppose you had some means of reversing the water's flow — then the surging back and forth in the coil would present a high resistance to any water trying to flow straight through.

The size and shape varies

Inductors vary a great deal in size and shape according to the frequency at which they are intended to work. For very low frequencies such as that of the 60-cycle power supplies and those of the audio spectrum, the problem of size becomes a difficult one. For these frequencies, inductances would be impossibly large if they were made of nothing but coils of wire. So, they are usually wound with an iron core; this makes a more intense field possible and brings the coil down to a reasonable size while still giving the same opposition (or inductance) as the coil having more wire.

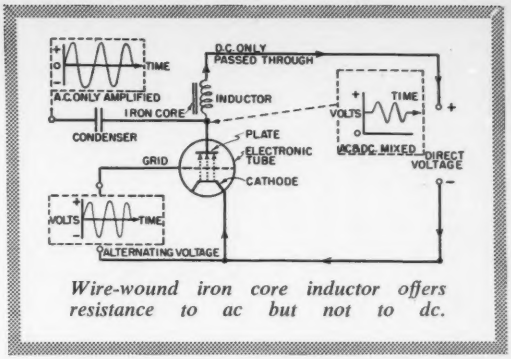
To go to the other extreme, at the very high radio frequencies, such as those used by radar or micro wave transmitters — even a straight piece of wire will have inductance and an inductor may consist merely of a kink in a straight wire. An iron core is certainly not needed here although for the lower radio frequencies inductors can be found using a core made of powdered iron mixed with a solidified plastic and molded.

The main value of the inductor in electronic circuits is its ability to stop the flow of an alternating current while allowing direct current to pass unhindered. This is important to the operation of electronic tubes where the direct current flow through the tube from cathode to plate has an alternating component impressed on it by the grid. Then d-c and a-c are delivered mixed in the plate circuit. By putting an inductor in series with the plate circuit we can remove the a-c supply through a conductor and allow the d-c to pass.

Inductors have not changed much since they were first designed. Those for radio frequencies are so simple that they hardly could change much. Lately, the use of printed circuits has brought about the greatest alteration in physical appearance. Inductors can be formed by an etching process whereby metallic plating in file form is deposited on insulating material.

Transformers are well known to the power engineer and probably to the general public since they are so often seen. But the electronics field is not concerned with the giant components found in power distribution systems. True power transformers are used in power supplies for electronic tubes — but these are relatively small and of very similar construction to those used in power distribution.

The requirements of the electronics industry for specialized transformers which can handle either a wide band of radio frequencies or various radio frequencies, has had the greatest effect in shaping the physical size and appearance of transformers.

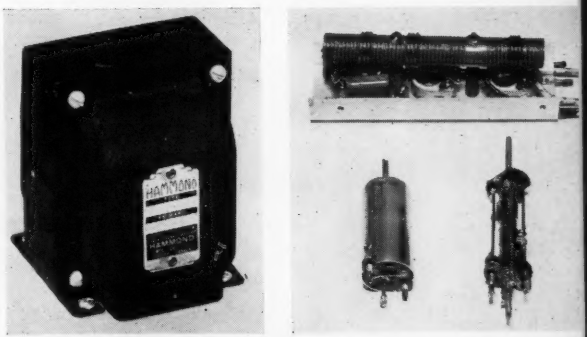


Wire-wound iron core inductor offers resistance to ac but not to dc.

The designer of a power transformer has quite enough of a problem on his hands but at least he is only concerned with its efficiency at a signal frequency. The audio transformer designer has not only to consider efficient power transfer, but must also do it over a band of frequencies covering the entire audio spectrum. This has led to intensive research into the best method of coil winding, the best magnetic material for the core and many other factors. The modern audio transformer will give a more or less even response over the entire audio range.

A transformer for radio frequency work is a vastly different matter. For one thing, it does not require the iron core necessary for audio frequency work and consists simply of two or more individual coils of wire. Radio frequency transformers are usually designed to operate either at a fixed frequency, or to present a high gain over a band of frequencies on either side of a centre frequency. This probably calls for condensers and resistors in various combinations which are usually mounted on insulated boards. The whole assembly is then enclosed in an aluminum shielding can. These cans will vary in size according to the frequency used, becoming smaller as frequency increases.

However, the general miniaturization of components, especially for aircraft, has led to the use of powdered iron movable cores. This makes the required inductance possible with a smaller coil of wire and



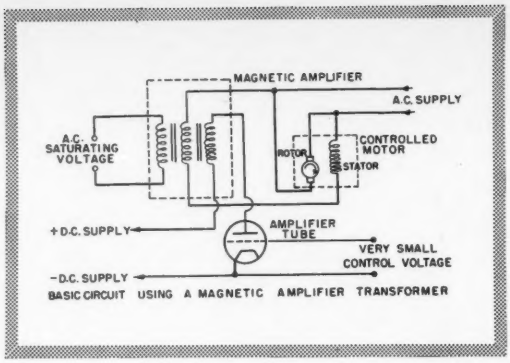
Left: A small-designed power transformer is pictured. Right: Top, radio frequency transformer with cover removed to show coils and capacitors; bottom, the small variable inductance RF transformer, covered, denuded.

tuning the transformer can now be done by screwing the core (or slug, as they are known) up and down. In this way variable tuning condensers can either be eliminated entirely or replaced by very much smaller fixed ones — giving a much more compact assembly.

A more recent component to appear on the horizon is a special transformer — the magnetic amplifier. In fact this component is not quite as new as is often supposed. It was used by power engineers to control automatically the speed of motors and the output of generators before electronic tubes were very much in use. But now it, and the electronic tube, have joined forces largely as a result of the trend towards automatic control.

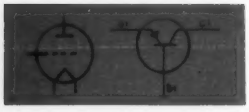
The principle is quite simple. By putting a third winding on the normal two-winding transformer and applying an a-c voltage to it, we can "saturate" its magnetic field. Now we have made it so strong that the iron core cannot take any more magnetism. Like most of us, when it cannot take more, it has a breakdown. But, as we have already said, the inductance of a coil depends on the existence of a magnetic field and as it has broken down, the opposition to the current flow has gone too.

So, to one winding we apply just enough voltage to keep it near the saturation point. To the second



BASIC CIRCUIT USING A MAGNETIC AMPLIFIER TRANSFORMER

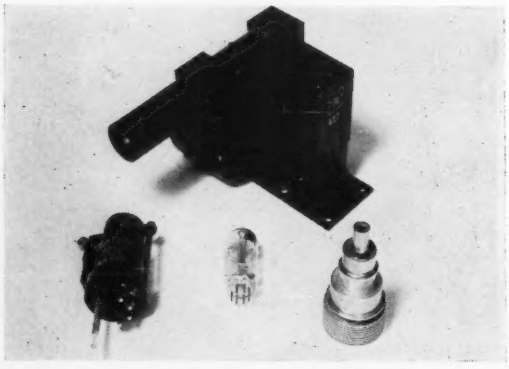
we apply a control voltage, either directly or through an electronic tube amplifier. The third winding is in series with whatever we want to control — an electric motor, for example. By varying the control voltage slightly on the second winding, we can saturate and de-saturate the iron core. But the small variation has a tremendous effect on the inductance of the third coil, and, in effect, amplifies the action of the control voltage. The variation in inductance of the third coil, will, of course, cause the speed of the motor to vary.



4: Tubes

LIKE MOST scientific discoveries it took several men many years to develop the electron tube. The work of Edison in 1883 on the emission of electrons from hot filaments (the Edison effect) made it possible for Fleming to produce the first two-element radio tube in 1904. However, it was not until De Forest produced his "Audion" three-element radio tube in 1907 that the radio industry began to grow. Only then did it become possible to amplify signal voltages.

The design of low and medium frequency tubes progressed rapidly with the introduction of screen grids, suppressor grids, coated cathodes. The movement was helped by a better understanding of the theory of electron emission and movement within tubes. Tubes in this class generally contain a filament to heat the cathode from which the electrons are emitted. A control grid placed between the cathode and plate controls the flow of electrons and makes amplification possible. The screen grid, between the control grid and the plate, isolates the cathode electrostatically from the plate. The suppressor grid (usually between the plate and the screen grid) prevents passage of secondary emission electrons from one to the other.



Top, magnetron; left, klystron for HF. Right, lighthouse tube for MHF; small centre tube for LF & MF.

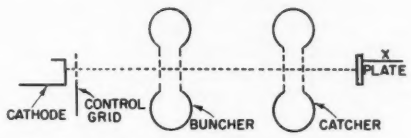
Within this low and medium frequency class there are also a number of complex tubes in which two or more tubes are enclosed in the same bottle. Some operate from a common cathode, while others are completely independent except for small capacitive effect between electrodes; this is generally so small as to present no great problem.

Power rating of tubes in the low and medium frequency class vary from the large water and forced air cool transmitting tubes down to the sub-miniatures used in hearing aids and other portable equipment. So with use of more efficient cathodes and more durable alloy plates, transmitting type tubes in general are now smaller in size for any given power rating. The receiving type tubes can also be had in new, more rugged, versions for reliable service in vibration and shock conditions. And many sub-miniature types have been developed for lower power and voltage amplification circuits. Some do away with the customary pin base and use, instead, wire leads that extend through the end of the glass body. The leads are soldered on-

to terminals in the circuits instead of being plugged in. Now, of course, changing a tube becomes more difficult but in most cases the tubes are used in expendable circuits or sub-assemblies that can be discarded rather than repaired; or the work the tubes are doing may be of a kind which allows them many hours before they are due for replacement.

As the operating frequency rises, these tubes become inadequate. This is due largely to the time needed for the electrons to travel from the cathode to the plate. When the operating frequency nears the transit time of the electrons, the tube ceases to function properly. This led to the development of tubes with closely spaced electrodes; but limits still remain due to inter-electrode capacitants and arcing.

Specially designed triodes with positive grids and negative anodes have been developed, but they suffer from low power output and poor efficiency.



Thinking afresh led to the development of the magnetron. If you build a tube by placing a thin cathode wire along the axis of a cylindrical plate, the electrons will travel radially from the filament to the plate. But placing the tube in a strong magnetic field tends to bend the electron paths until a critical voltage — magnetic field strength — is reached at which the electrons just miss the plate. If the plate has a series of cavities on its inner surface, the electrons will set up oscillations within the cavities as they pass each opening. In this way d-c applied to the cathode is converted to high frequency and tubes are now available that can deliver fairly high (several megawatts) peak power when operated intermittently. The frequency is given by the physical dimensions of the cavities and is very stable. The output signal is taken from the cavities by suitable probes or wave guide openings.

Another high frequency tube is the klystron. Like the picture tube in your TV set, the klystron has an electron gun that emits electrons in a thin stream down the tube. As they pass through the grids of the buncher resinator they are velocity-modulated by the a-c signal at the buncher.

Some electrons are speeded up while others are slowed depending on the phase of the signal at the instant each electron passes the grid. In the space between buncher and catcher, the electrons form into small groups that pass through the catcher, exciting the catcher resinator. By applying a signal to the buncher, amplifier action results with the signal output being taken from the catcher. By feeding part of the signal back from the catcher to the buncher, the tube can be made to oscillate. The operating frequency comes largely from the physical sizes of the buncher and catcher cavities. Several refinements exist but this broadly is how the tube works.

Gas filled tubes form another group that is characterized by their high current handling abilities. With this type, when the gas is heated and the voltages on the grid and anode reach certain critical values, the gas ionizes allowing large currents at low voltages.

Two other specialty tubes have also come forward —photo tubes and radiation counter tubes. Photo tubes are sensitive to light in and near the visible range so that light striking the sensitized electrode sets up a small current flow. This can be amplified for many uses. The current craze for uranium prospecting would not be taking place if it were not for the radiation counter tubes. They are sensitive to beta and gamma rays.

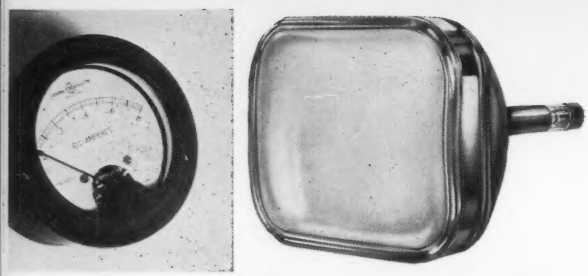
The development that caused the greatest excitement during the past few years is the transistor. It had its beginning more than a century ago in the form of crystal detectors such as you probably used on your old crystal set. But these were just detectors—the equivalent of two-element tubes and could not amplify signals. Transistors, unlike tubes, are current amplifiers but at the present time are capable of handling only small amounts of current.

Transistors are finding their greatest use in low power circuits such as computers and hearing aids. They do not require any heater current and so are economical in use. However, they are a little noisier than tubes and are still expensive because of manufacturing difficulties. Their assembly is still a hand operation done under a microscope. But you may be sure these problems will be overcome and when this has happened transistors will undoubtedly replace a number of our present day vacuum tubes.

5: Meters & Indicating Devices

ONE OF THE most annoying habits of electronic devices to people not familiar with them (and sometimes to those who are) is that they look exactly the same whether they are working or not! The faint red glow from an electronic tube is the only clue to the fact that it is at work. There is nothing to show that a myriad of electrons are moving at incredible speeds. Even if they could be seen physically, the human eye is far too slow to follow operations taking place in millionths of a second.

To be able to get best working efficiency we must apply meters at strategic points, as power engineers do, to check voltage and current flow. In an electronic circuit, however, we must face the disadvantage that current flow is usually very small (thousandths or millionths of an ampere) and the placing of a metering device often causes changes in the working characteristics—or even stops the action of the circuit altogether. Also, the operation of the circuit can vary at such a high frequency that the ordinary moving milliammeter cannot follow it. Its mechanical inertia will cause it to remain stationary and electrical engineer has a problem.



Left, close-up picture of a typical design d-c ammeter. Right, cathode ray tube, essential in electronics labs.

In electronic circuits, therefore, we usually study the effect of the circuit operation on d-c current flow, instead of trying to watch the process directly. The cathode ray oscilloscope gives us a way of seeing circuit operation directly — but for general use observation of effect is good enough.

Probably the best example of observation of effect is the method used to find when a tuned circuit is exactly at the point of resonance. A resonant circuit consisting of an inductor and condenser combination possesses the property of offering a very hard resistance at one frequency. This frequency can be found by applying the electrical values of the inductor and condenser to a suitable mathematical formula.

Assuming the frequency to be constant, then either C or L or sometimes both, are physically varied until their values coincide with those required to give the same value of frequency. When this point is reached the circuit will offer its maximum resistance to current flow. To study this effect, we can either connect a milliammeter in series with the power supply to the circuit, or, if the current flow is quite small, we can put a small resistor in series and by means of a microammeter or millovolt meter, read the voltage drop across it. As we vary either the condenser or inductor the current through the circuit will gradually drop as the point of resonance is approached—and it will start to rise again as it is passed. By adjusting the circuit constance to give the minimum reading on the meter we find we have a handy method of making sure that the circuit is on resonance and working at its optimum efficiency.

Special types of measuring instruments using electronic tubes have been developed to deal with highly sensitive circuits for even the use of these methods would upset or stop the functioning of the circuit. A whole book could be written about test equipment of this type as it has become very complex developing into a whole new field of its own.

The vacuum tube voltmeter will probably be familiar to a great many readers. In its simplest form, instead of the micro ammeter being applied directly to the current under measurement, it is connected in the plate circuit of a three-element tube while the voltage to be measured is applied to its grid. This not only gives greater sensitivity in measuring small voltages, due to the amplifying effect of the tube, but has little effect on the working characteristics of the measured circuit. This is because it does not draw current and its internal electrical capacity can be made negligible. However, most of the measurements we have mentioned depend for their accuracy upon the fact that we know the waveform of the circuit to be sinusoidal in nature. If the wave were to change its form, vastly different readings would be found.

Television, radar and modern methods of multiflexed communication brought about the use of circuits using anything but sinusoidal waveforms. Square, triangular, saw-toothed and other shaped waves began to appear and the proper operation of the equipment often depended upon the wave shape being exactly correct. To meet this need the cathode ray oscilloscope was developed. It is an intricate instrument using as its basic indicating device the cathode ray tube and it has become an essential tool in the electronic workshop.

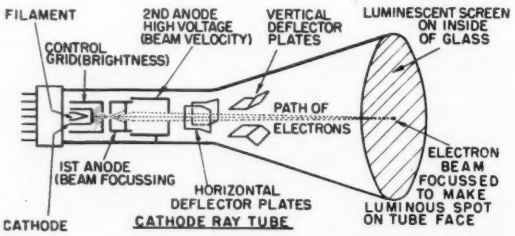
The cathode ray tube is a clever adaptation of principles of the ordinary electronic tube. Normally, electrons are emitted from the surface of the heated cathode and are attracted to the anode of plate by a positive charge. In the cathode ray tube, however, special beam-forming and focusing elements are used to form the electrons into a fine beam. Also, a very high voltage is used on the second anode of the tube to measure the speed of the electrons. They are then allowed to escape through a hole in the anode, carried on by their velocity until they strike the screen and cause a bright luminous spot to appear.

The plates come into their own

At this point the deflector plates come into their own. The electron beam possesses the property of being capable of dissection by an electrostatic or magnetic field. Suitable voltages applied to the deflector plates will cause the beam to move and, of course, the luminous spot with it to any point on the screen. We now have a modern version of the "moving finger" of Omar Khayyam fame. But our finger has the great advantage of being composed of weightless electrons and so has no inertia to be overcome.

Now, at last, we have an indicator which can respond to a-c currents of any frequency. By applying an a-c voltage or "sweep" of a suitable frequency to the horizontal deflecting plates, the beam will move backwards and forwards although the eye will see only a horizontal line. If we connect the waveform that we want to see to the vertical deflection plate, then the beam will draw us a graph of it in terms of the time base represented by the "sweep".

The cathode ray tube is a modern Aladdin's Lamp which can be made to perform many formerly impossible tasks. The television picture tube is nothing more than a highly specialized oscilloscope and the picture itself is a presentation of waveform phenomena. The cathode ray tube was originally made for laboratory and oscilloscope work and for that reason had the round screen. In the



A cross section view of cathode ray tube. The broken lines indicate the electron beam path.

early days of TV production of tubes for oscilloscopes outnumbered those made for TV—which is why early sets had round screens. Now, of course, the position is reversed.

Radar would have been impossible without a method of measuring the millionths of a second taken for an echo to return from the target. Only the weightless electron beam could move with enough speed to measure the extremely small time interval involved.

In the latest field, computers and automation, a special version of the cathode ray tube is being used as a memory for electronic brains. A voltage value, representing a figure, can be stored at a position on a specially made screen until required. It will then have a position reference in terms of the voltage applied to the horizontal and vertical deflector plates at the time. Later these same values can find it again when it is needed for use in a calculation.

6: Motors, Generators & Selsyns

WHEN Michael Faraday was experimenting with electric current flow, in 1831, he found that when a conductor was moved in a magnetic field, a current was caused to flow. Until this time the only means of creating electric current had been by batteries of chemical cells. He realized that his discovery could lead man to a source of power greater than anything previously known.

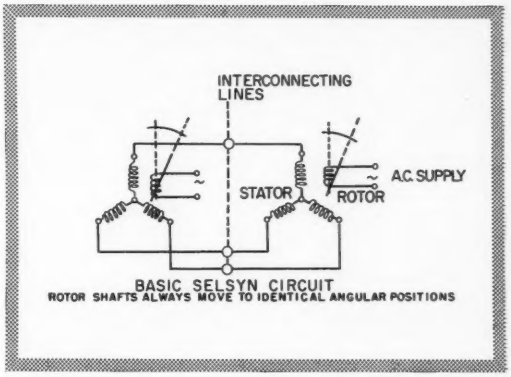
Nature's secrets always seem to be revealed in pairs; and Faraday's discovery complemented that of Oersted's, of eleven years earlier, which showed that mechanical motion could be had from a current-carrying wire in a magnetic field.

Although Faraday knew the importance of his find he would have been staggered if he had seen our vast power industry of today, and if he had known of the complexities to which his simple experiment led.

Motors and generators for many years were not noticed by the rapidly growing electronics industry — except as a source of voltage when their regular methods of batteries or rectified a-c could not be used. The growing use of radio communication in aircraft and, more recently, between vehicles and fixed stations, gave designers the problem of finding d-c voltages of anything up to 1,500 volts to operate the tubes of their transmitters and receivers.

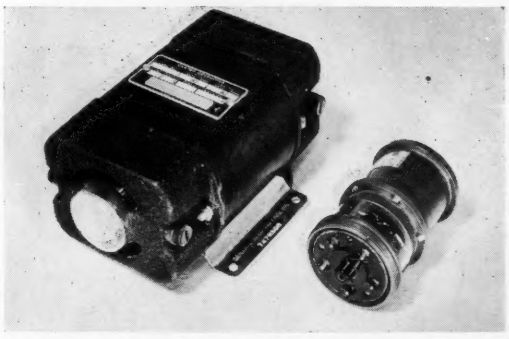
Separated from their beloved 110-volt 60-cycle a-c supply, which could so easily be stepped up and rectified, designers were faced with low voltage d-c supplies. The ordinary motor generator combination would, of course, supply the need — but at great cost in weight and space.

So the dynamotor was developed. This machine, weighing less than the two separate machines needed in older days, consisted of a single stationary field-winding and a single armature with a commutator at either end. On the armature two sets of electrically separate windings were interwound. The input winding would be connected via one commutator to the low voltage d-c supply with the common field in parallel. The output winding would have many more trials and turns and would be connected to the other commutator. The result of this would be that the input side would act as a motor but, as the armature turned, it would also cause the output side to act as a generator — the common field providing excitation for both sides. This gave the nearest equivalent of a d-c transformer as the turns ratio of the input armature winding to that of the output winding would control the ratio of input to output voltage. A typical machine of this type might have an input of 6 volts at 50 amperes and an output of 600 volts at 280 miliamperes.



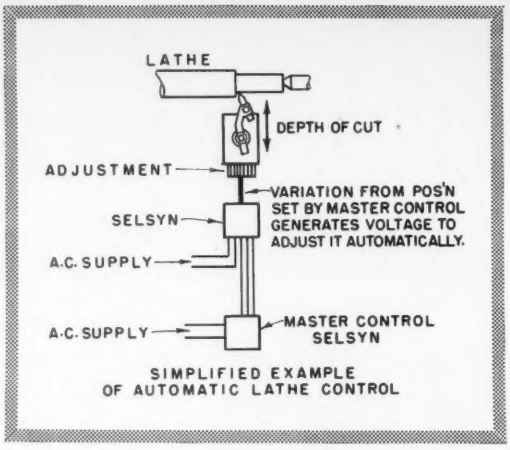
It is difficult to find out whether the development of the selsyn motor was first brought about by aviation needs. Certainly World War II requirements in the fields of radar, fire control and guided missiles brought about such tremendous concentration of this descendent of the conventional motor and generator, that now we have a bewildering number of shapes and sizes from which to choose.

Selsyns or any of their predecessors, are a reversed

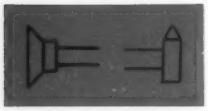


A genemotor, combining generator and a motor is shown in its typical design in photo, left. Right, a selsyn.

version of the conventional motor or generator. Instead of having a stationary field and movable armature coils, it is the armature coils that are fixed and the field that is rotatable. Result of this is that the armature coil which is physically closest to the field will have the highest voltage developed in it, and corresponding voltage distribution over the parts of the fixed windings. So, for every angular degree of rotation of the movable field, there is a unique combination of voltage and field distribution. If we connect another similar machine in parallel with the first with windings having the same electrical and mechanical relationship, we shall get a reproduction in the coils of the second of the field existing in the first. But suppose that the movable field coil of the second machine has a different angular position to that of the first, then, a torque will be exerted tending to make it correspond to this angular position. Moreover, the amount of torque is proportional to the degree and speed of the angular change. This description applies to the basic selsyn circuit but it has many variations developed for different purposes. Its main interest is that in effect it gives man electrical fingers to carry out an operation, or to feel if it is being correctly performed. Its future seems to be greatest in the field of automation where it can control the operation of lathes for example. Not just one machine, but a whole factory can be made to follow a master pattern and to report individually upon the accuracy of their operations. Feed back signals as these reports are known can come from many sources. Some may come from other selsyns, as in the case of automatic pilots, or from special potentiometers. And looking skyward, they may come from radar echoes or radio signals — as in guided missiles.

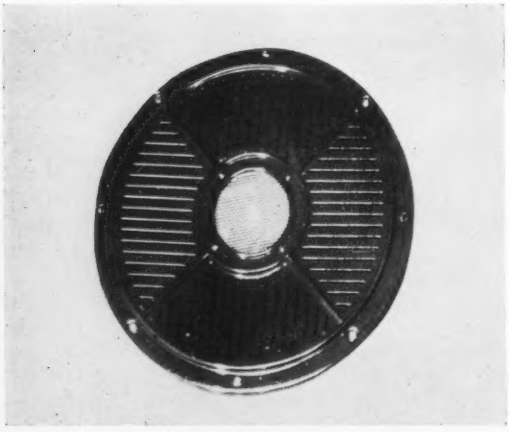


SIMPLIFIED EXAMPLE OF AUTOMATIC LATHE CONTROL



7: Microphones, Pickups & Speakers

MOST OF US who are old enough to have dabbled with crystal sets during the late 20's can remember the earphones which were needed to complete the set—probably we remember them best for the heavy strain they put on our limited budgets. What is perhaps not realized is the vast variety of gadgets depending on their magnetic principle of operation that have since been developed. The most familiar of these (and it is the next evolutionary step) is the loud speaker. From a simple coil, carrying audio frequency currents and suspended freely in a magnetic field, it has developed into huge instruments for theatres, public address systems and for hi-fi fans.


Tweeter for notes above 1800 cps is mounted on woofer frame in 12-in. dual coaxial high fidelity loudspeaker.

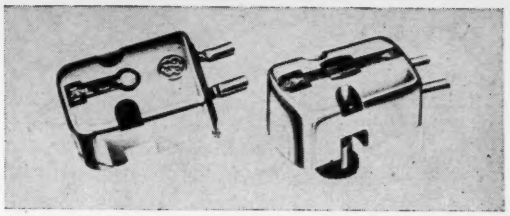
Moving to the other end of the high fidelity chain, we have the pick-up head (another largely magnetic device) that translated the mechanical movement of the needle in the groove of the record into electrical equivalents of the sounds represented by them. These devices were originally magnetic in nature and compared with those of today were impossibly heavy—weighing sometimes as much as ½-lb. Most of this weight was due to the heavy permanent magnet required to produce a magnetic field of reasonable intensity. Largely for this reason, a drift to the crystal pick-up head took place.

The crystal head consisted of a slice of quartz pressed between two flat plates, one of which was attached to the phonograph needle. Movement due to the grooves being hollowed caused pressure on the crystal to vary according to the sound waves on the record. When pressure is applied to a crystal of this type it generates a minute voltage; so pressure variations give small voltage changes which can be amplified. However, the pendulum seems to have gone full swing and currently a modernized version of the old magetic pickup head is *a la mode*. The so-called variable reluctance cartridge is much lighter, weighing only ½-oz. and having twin needles—or styli as they are now dubbed. The old steel needle has practically disappeared and tiny splinters of sapphire are generally used. This has mostly been necessary by the microscopic grooves to be found on the 33 1/3 rpm records which are easily damaged by poor needles or excessive pick-up weight. The metallurgists have made

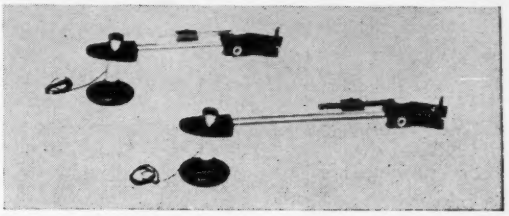
a huge contribution to this—as to all things magnetic —by the developement of the new alloy alnico. This alloy will allow a higher magnetic field to low weight ratio than anything known before and so the chief bugbear of the early magnetic pick-up has been removed.

For all this, it seems that the phonograph pick-up head may one day exist only as a museum curiosity in the light of the latest challenger to appear. The modern tape recorder seems to have a bright future ahead. Originally it was developed using a length of steel wire or tape as the recording medium following the principle that if the tape or wire is drawn over a tiny gap in an otherwise closed magnetic circuit, then a replica of the field strength will be left on that part of the tape which bridged the gap at that instant. If we vary the magnetic field of the "recording head" by applying a sine wave or other audio frequency combination to its field coil, we shall obtain, in effect, a graph in terms of field strength against time of the original sound. By passing the tape over another similar magnetic gap the process can be reversed and voltage fluctuations in the coils can be had in exchange for the field variations.

The great advantage of the tape recorder is that recordings can be made and instantly played back; then, if they are no longer needed, they can be wiped off the tape by the simple means of electrically destroying the series of fields that represent them. This is easily done by applying through another head, high level, high frequency alternating voltage. By placing the three heads strategically along the line of tape travel, the three operations can take place in logical sequence: erase, record, and play back. In this way we can take a tape having some other matter on it and place it on the recorder with the assurance that before our new material is recorded, the old will have been wiped off. Then, immediately after recording, we can listen to a play-back of the new material. The earlier recorders used steel wire or steel tape; this has now been completely replaced by a tape made of plastic material impregnated with fine particles of iron oxide.

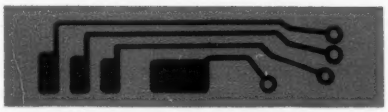


Two variable reluctance cartridges with calibrated counterweights to compensate for varying cartridge weight.



Top, single stylus plug-in variable reluctance cartridge; below, dual stylus for standard or microgroove.

Apart from the obvious mechanical advantages, such as ease of handling and jointing, modern plastic tapes are capable of much improved frequency response. These improvements have taken recording right out of the audio range and have given suitable tape with recording speed into the realm of radio frequencies. The sharp edged, square wave pulses required by a TV picture signal require a frequency response up to 4 millions cycles per second—but even this is not beyond the capabilities of latest experimental recorders.



8: Wires & Printed Circuits

ONE OF THE oldest jokes about radio is based on the incongruity of its early name "wireless." Certainly to see the maze of criss-crossed wires underneath the chassis is a reminder of how much today's electronic marvels depend upon the humble piece of wire.

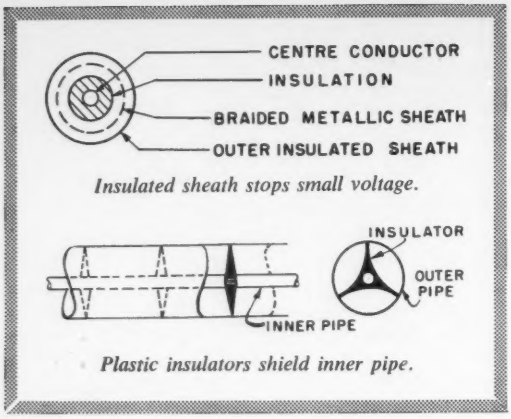
The ordinary rubber, plastic or fabric insulated wire has its place as a means of feeding direct current, or low frequency a-c power supplies, to electronic circuits. But the use of higher and higher frequencies in radio communication leads unavoidably to the point where a voltage cannot be contained within a metallic part, but must radiate into space. Also, the increasing sensitivity of electronic equipment has made it susceptible to interference from minute electrical disturbances that were not even known to exist before.

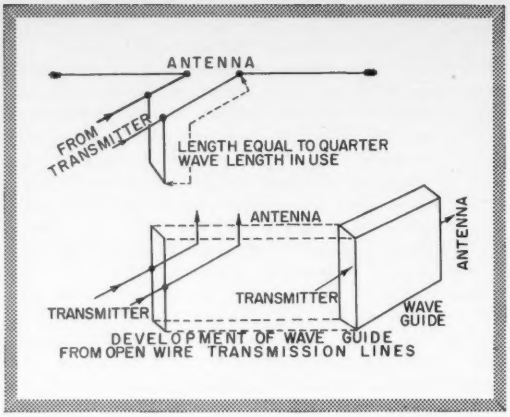
This has led to a vast variety of special cables being developed, each one designed to allow some particular band of frequencies to be passed without serious attenuation, or to prevent some specific interference.

The interference effect is first noticed in high grain audio amplifiers where the input voltage is usually in the region of a few thousand volts. With the increased use of electrical apparatus of various kinds, there is hardly anywhere that does not have an alternating electrical current in existence. This field, picked up by connecting wires, is amplified several thousand times and emerges as a hum of horrifying dimensions! It is for this reason that so many types of shielded cables exist. Their general purpose is the same — to introduce a grounded body between the source of interference and the sensitive input connections.

Usually a flexible braid covers an insulated inner conductor; but in some cases the amplifier sensitivity may be so high that even the rubbing of the grounded outer braid on nearby metal objects can generate small voltages and cause crackling noises. To overcome this, nearly all cables of this type have the shield itself covered with yet another insulated sheath.

As we go higher in frequency, into the realm of radio, we find that a cable of the co-axial type makes an excellent means of conveying radio frequency voltages from one place to another without their being





lost in transit. The outer grounded shield confines the voltages to the inner conductor. A transmitter can be coupled to an antenna with the assurance that all the power will go into the antenna and will not be lost in the transmission line.

The main difference between an audio and a radio shielded cable is the quality of the insulation between the inner and outer conductors. Chemistry, with its huge variety of plastics of the polyethylene family, has produced most efficient insulators which make possible the design of flexible co-axial cables to work without serious loss up to as high as 200 million cycles per second.

Above 200 megacycles, the efficiency of solid insulators fall off hurriedly and some other method has to be found.

Reduce the solid insulation

At these frequencies, and up to the realm of microwaves, the amount of solid insulation has to be reduced to the minimum amount needed to support the inner conductor. The hollow inside of the outer pipe is filled with dry air, or nitrogen, under pressure. The inner and outer conductors are now solid concentric copper pipes and the tools used by technicians on this type of installation are like those of a plumber. The coming of radar and higher frequency microwave systems brought bands of radio frequencies into use up to 10,000 megacycles and above.

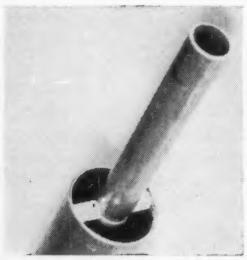
At these frequencies power loss, even with the solid copper cables, became too high to be tolerated. As the insulation had previously been cut to a minimum, now came the idea to do away with it altogether. Yet, if this were done there would be nothing to support the inner conductor. Very well! Remove the inner conductor also. But it was not possible to make the change so simply.

A new approach had to be taken where the dimensions of the new conductor were inversely related to the frequency in use. Before, frequency of operation had had no effect on the diameter of circular cables. The only effect of increased diameter was to reduce losses. The new style of conductor became known as a wave-guide; this is a more accurate description of its function.

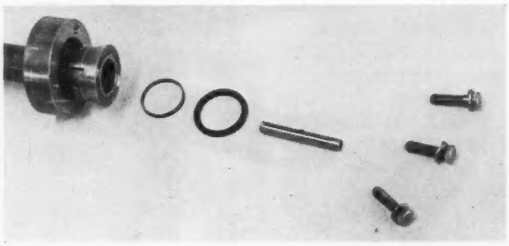
It is usually rectangular in section and is derived in an interesting manner from the practise of using short pieces of wire, proportioned in length to the frequency in use, as impedance matching devices on open wire transmission lines.

The natural laws governing wave-guide operation fitted in well with designers' requirements. As the operating frequency went higher, the wavelength became smaller — and the dimension of the wave-guide fell within reasonable limits. Moreover, it is just at these particular frequencies that the inherent low power loss characteristics of the wave-guide is most urgently needed.

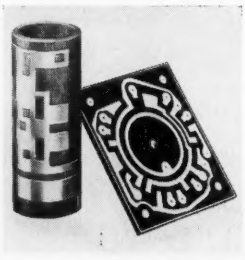
A survey of the various methods of wiring and conveyance of power would not be complete without mention of the latest method of printing circuits as metallic deposits on sheets of insulating material. (This subject was covered in detail by DESIGN ENGINEERING, June issue.) By means of a skilfull blend of photography and printing arts, the designers' circuits are



Transmission line: inner, outer conductor, beads.



Coupling for transmission line showing inner and outer conductors, coupling flange and pressurizing ring.



Copper - clad phenolite drum, plate, circuit-etched.

literally transformed from the drawing board to actual reality.

Great compactness comes from this. But that is not all — there is also a tremendous drop in wiring errors, a serious bugbear of electronic equipment manufactured in the conventional manner. Also, components such as inductors and capacitors can be either formed by suitable design of the deposited metal, or specially made to be capable of being easily and quickly installed.

A saving of assembly time, too, comes from soldering all connections at one time by dipping their extended contacts into a bath of molten solder.

The lightness and compactness of these circuit assemblies are of much interest to designers of electronic equipment for aircraft and guided missile use. And their other feature, cost reduction, has appealed to designers of equipment for the competitive markets — such as TV receivers.

9: Antennas

UNTIL TV demanded more critical links in the radio frequency chain that joins transmitter and receiver, the antenna was probably the most neglected unit. A modern radio receiver will work with almost any piece of wire used as an antenna, but it can only operate under these conditions because of the extreme sensitivity of the set and the great strength of the average broadcasting signal.

In radio communications work, however, as opposed to radio broadcasting it is not enough just to be able to receive the signal. As a matter of fact, the average broadcast set operates at very low efficiency and wastes power. Radio communications, being a business, cannot allow wastage in any form and, even though the most sensitive receivers are used, they will not work with the maximum effect unless an efficient antenna is used.

The size of the transmitter used in radio communications, depends on the signal strength needed at the receiver for good, consistent reception. It is generally necessary to square the transmitter power just to double the signal strength at the receiver. So, if a communications company can find ways of making less powerful signals effective, transmitter cost savings can be made.

Broadcasting suffers a handicap that communication work does not. A broadcast sends out its signal in all directions, diffused over a wide area; but communications companies usually want to transmit in one direction only. A suitable antenna will concentrate the power in this direction and save some of the energy which would otherwise be diffused and wasted by a blanket transmission.

The basic theory of antennas is such that radio frequency is best radiated from a piece of conductor having a length half that of the wave being radiated. It is known as a half wave antenna.

In the range of frequencies used in broadcasting the wire would become too large. A half wave piece of wire at a frequency of 600 kilocycles, for instance, would be about 800 ft. long. Therefore, on this frequency range, the antenna is usually "loaded" by a coil of wire to make it electrically longer.

The relationship of wavelength to frequency is governed by the propogation speed of radio waves, which is the speed of light, 186,000 miles per second. Converted to meters, the speed is regarded as 3×10^8 meters per second. By dividing wavelength of frequency into this figure, one to the other can be readily converted.

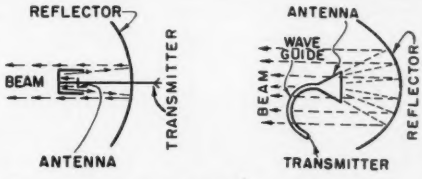
As the frequency increases, the physical size of a half-wave antenna decreases to a reasonable length so that there is enough space to arrange banks of half-wave pieces of wire, radiating together in the same direction. This prevents the power from being scattered.

Energy can also be concentrated so that it may be radiated in a beam by placing other half-wave lengths of wire at suitable distances from the antenna. These reflectors capture the radiation from the rear of the antenna and make it a one-way device.

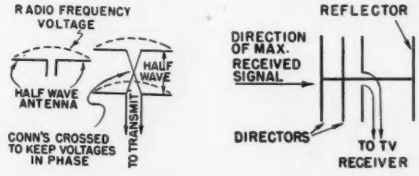
Other lengths of wire known as directors placed in front of the antenna will further increase radiation in the right direction.

This type of antenna is called a "Yagi" and is the mainstay of television receiving antennas, the various elements being made of aluminum tubes instead of wires.

The direction finder loop antenna gives a minimum signal when the axis of the loop is at right angles to the signal it is receiving. Conversely, it will give a



Left, microwave dish antenna like searchlight, and right, radar antenna with a wave guide.



Left, half wave antenna hook-up; right, the aluminum tube Yagi increases signal strength.

maximum signal when the loop axis is in line with the path of the signal. The former principle is used in marine and other airborne direction finders, and the latter is used in portable domestic sets.

The microwave dish antenna is an interesting example demonstrating that as radio waves become higher in frequency they behave more and more like light. The antenna, in fact, resembles the optical systems of some types of searchlights.

The radar antenna, produces a very intense radio beam. It is designed to allow energy to be projected from the end of a wave guide and shaped by a suitable reflector to the kind of beam needed for the type of radar.

Different types of radar require different types of beams, according to the kind of presentation for any particular job.

The dimensions of all antenna of these types are extremely critical. A vast amount of complex mathematics governs their function but still they all remain variations of the simple half-wavelength piece of wire so useful to the amateur.

10: Connectors & Terminals

SOMETIMES an old radio is found tucked away in the corner of an attic steeped in dust and memories. Many of them can still be found, particularly in the rural districts where they continue to bring pleasure long after their city cousins have been replaced by modern "superhets."

A feature of these early masterpieces was the many large brass terminal posts scattered throughout the chassis — the mark of an era of plentiful brass and hand assembly. So once there was a time when designers were working on problems other than those coming from high frequency and power, vibration and shock, space and weight limitations and a scarcity of material and skilled labor! But these are today's worries and the big brass terminals have disappeared. In their place are a myriad lugs, plugs, jacks, connectors, clips, terminals and sockets.

The lug is used on the end of single, low frequency conductors to form a mechanically strong termination that can be fastened into screw or clamp type terminals. They were originally designed to be soldered to the connector, but now they have been largely displaced by terminals that are fastened to the wire by crimping.

The brass binding posts and terminals have been replaced by types using steel and aluminum as conducting parts, with bakelite, ceramic and mica-filled phenolic.

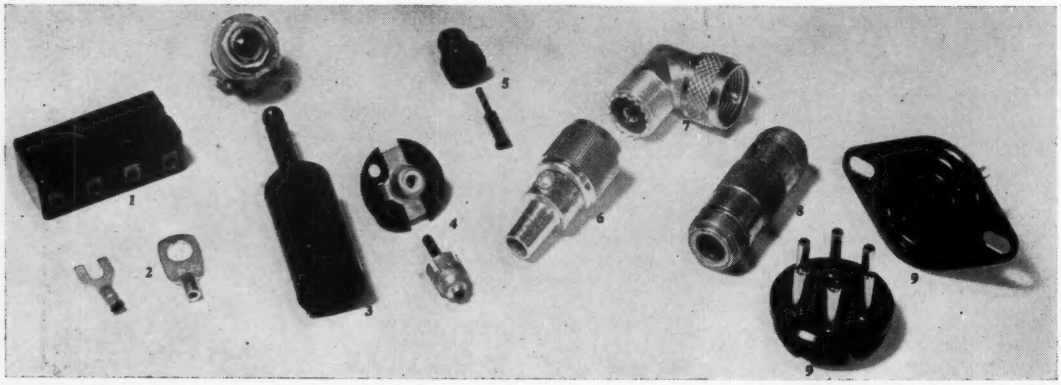
Where connections are meant to be semi-permanent as in the case of interconnecting cables inside a transmitter cabinet, screw or clamp type terminals are used on the terminal board.

The Bell Telephone Laboratories have developed a small pistol shaped tool that joins wire onto a terminal post by winding it tightly around the post three or four laps. This lets the serviceman make good connections quickly and it eliminates the old danger of searing the adjoining wires or ending up with cold solder joints.

Rapid and frequent connecting and disconnecting of cables and chassis has led to numerous types of plugs, jacks and connectors. In the low frequency range some of the more common connectors are battery clips, alligator clips, crocodile clips, banana plugs and jacks, cord tips and jacks, and phone plugs and jacks.

These are generally made to handle a single conductor, although some are built to cope with two or three. Those designed for audio signal lines require self cleaning contacts to avoid impedance change from oxidation of the metal. The cleaning is done by rubbing the contacts together as in thrusting a telephone plug into its jack.

With high frequency signals the plugs and connectors are more elaborate. Such names as co-axial, N, BN, BNC, and AN connectors introduce several

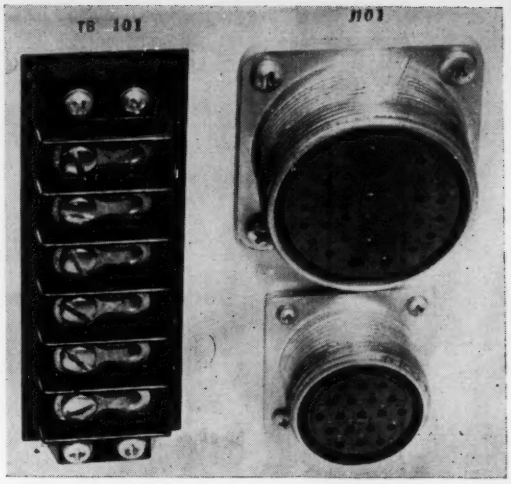


1. terminal block; 2. lugs; 3. phone type jack, plug; 4. audio frequency jack, plug; 5. metering circuit, jack, tip; 6. RF connector-cable style adaptor; 7. right angled RF and 8. straight body RF connectors; 9. multi-pin connector.

high frequency connectors characterized by their high insulating properties and their relatively constant impedance. In general they are tubular in shape with a single inner conductor insulated from the outer body by a high frequency insulating material such as Teflon, mica-filled bakelite or polystyrene.

The outer shell is threaded so that the connectors can be screwed together, ensuring tight union. Some models are equipped with watertight seals. The design includes a complete range of straight male and female connectors, right-angled connectors, and T connectors and adapters for joining different types of cable. Each connector is built for use with a specific cable.

In the low frequency field, the electronic engineer now has at his disposal a wide range of multi-wire connectors. Probably the most familiar is the two-prong plug used on toasters or irons. The multi-contact plugs and sockets, used where vibration and shock are not serious factors, are built on the same principle and rely upon the contact pressure to keep the connectors in place. Mobile equipment, particularly in aircraft, introduce such a serious vibration problem that the connectors must be held together by a clamp or screw.



Left, a barrier strip terminal board, and right, two multi pin connectors are shown with threaded jackets.

11: Sockets

THE WORDS "connector," "plug," "jack," "receptacle" and "socket" rank high on the list of misused electronic terms. In spite of attempts by engineers to define these words, the average technician still prefers to use the first word that comes to his mind.

One school of thought associates connectors, plugs, jacks and receptacles with joining wire and cables. Sockets are spoken of in conjunction with plug-in components such as tubes. Other people may choose to associate sockets with cable plugs.

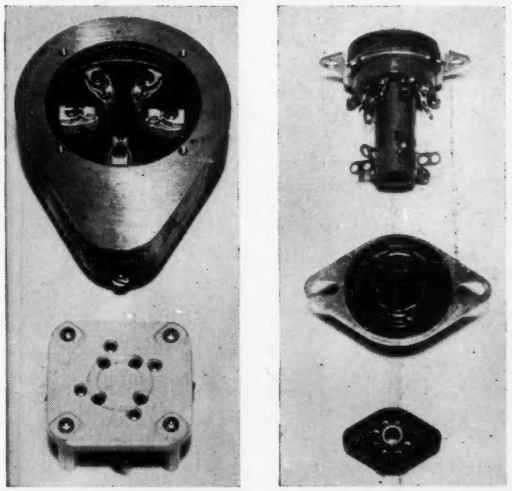
Since tubes were the first components built with a pin base for rapid changing, it is natural that they were to establish the pattern for sockets. Other components have subsequently been built to use the same sockets with some variations. As tube designs changed from the old standard, four-pin base to six, seven, eight or more pins, the corresponding sockets were produced. As tubes were miniaturized, enlarged, constructed for high voltage and frequency, the types increased.

The socket bodies are generally molded from ceramic, steatite, bakelite, mica filled bakelite, or similar material having the properties of high insulation, low moisture absorption and high tensile strength. The contacts, which are molded or fastened into the body, are used to hold the component firmly in place as well as to provide the electrical contact. Silver plated phosphor bronze is a popular type, where the plating prevents oxidation from building up insulation and the phosphor bronze provides a sufficient "spring" to grip the mating pin securely.

In mobile and airborne equipment, or in places where there is vibration and shock, sockets incorporate some type of clamp to hold the component in place. In high voltage circuits, the sockets are set at the bottom of a deep insulated shell for safety.

Sockets that have insulated centre posts extending down from the bottom are becoming very popular, particularly in chassis where space is at a premium. There are terminals fastened to the post on which the circuit components associated with the lug-in component, which is usually a tube, may be neatly connected directly. The group can be assembled separately, then fastened into the chassis, a feature that speeds up production.

Sockets, and the terminals and connectors already described (Section 9) are providing the means for rapid assembly and repair of electronic equipment.



Left: Top, high voltage socket for transmitting tube; bottom, ceramic socket for HF circuit. Right: Top, an insulated turret type; below, a standard, mini-waifer.

12: Switches & Relays

FUNDAMENTALLY, a switch provides control by allowing the operator to complete or "break" an electrical circuit at will by closing or opening the switch. This can be done by taking one of the wires in the circuit, cutting it apart, and then holding or twisting the two ends together to complete the circuit or parting them to break it. But the method is dangerous and impractical where high voltages and currents are involved.

Even with low current passing through the circuit, the bending of the wire as the operator opens and closes the circuit tends to break it off. These disadvantages outrule make and break contact by joining the wire, particularly when switches are so easy to install and use.

Great strides have been made in the design of switches during the past few years but the knife switch, one of the originals by designers of yesteryear, is still used widely throughout the electrical industry. Many subsequent designs are patterned after the knife switch.

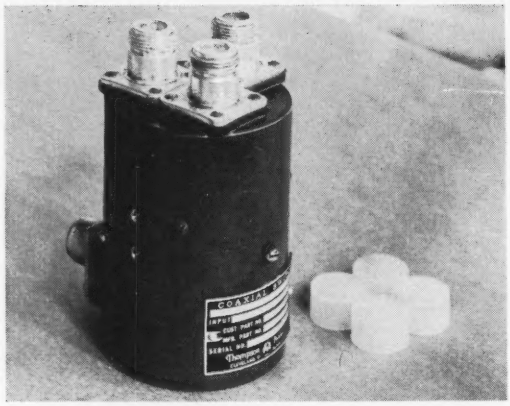
There are only a few basic types of switches: There are numerous sub-types or variations derived from such features as different actuating mechanisms, number of circuits to be switched, power ratings, contact materials, types of insulation, and methods of mounting.

The first basic type is a modification of the knife switch. It consists in its simplest form of a bar that snaps in against two contacts to complete the circuit or, out — to break it. The moving contact is generally actuated through a spring mechanism to give a fast make and break action. This reduces the damage to the contacts from arcing.

Toggle, pressure lever, sliding lever, and key switches, as well as some of the push button and rotary switches belong in this family. Micro switches are first cousins and derive their name from the short movement of the actuating lever; 0.002 in. is a typical movement for positive "on" and "off" action.

The second basic type has sliding or wiping contacts. Rotary switches are typical examples where the moving contact, attached to the rotating shaft, can be turned to make connection with any of the stationary contacts. Multiple or ganged switches can be built by mounting several sections on the same shaft.

The third type has its contacts mounted on the end of spring metal cantilever arms. These have been used extensively in telephone lever key switches and in relays.



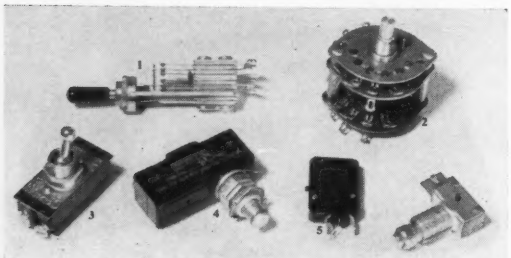
A coaxial relay with terminals built to fit the standard coaxial connectors is shown in the above photo.

The general trend in switch design has been to reduce size by using improved insulation and to increase the service life by the use of alloys. The contacts in particular are subject to damage through arcing, mechanical wear, heat and misuse. Many switches have been ruined by an inexperienced person who attempts to clean the contacts. The alloy used on the contacts depends upon the intended use of the switch. Some produce very hard contacts that resist mechanical wear, some resist tarnish, and others produce contacts that are capable of handling high current without overheating.

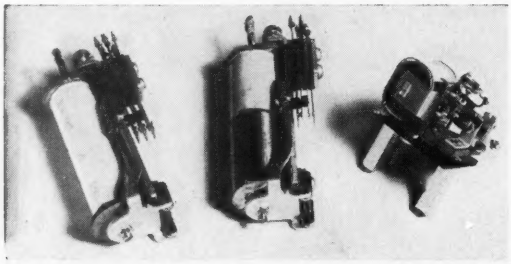
Switches that can be built up from flat sections such as the rotary selector switches, lend themselves to mass production. The stationary contacts can be printed directly in as part of a general printed circuit and the moving contact added.

A relay is a switch with an electro-magnet attached to move the contacts. The majority have spring type contacts but they are also available in numerous other forms — including mercury contacts and micro-switch contacts. These switches are attached to the armature which is moved back and forth by the electro-magnet.

Relays can be designed for either a-c or d-c opera-



Switches: 1. telephone; 2. rotary; 3. toggle; 4. & 5. micro switches; 6. push lever switch.



Left to right: Instant operating relay; relay with a brass collar for short time delay; fast acting relay.

tion in a wide range of current, voltage and frequency ratings for both the coils and contacts. Shape, weight and mounting can also be adapted to various conditions.

Every relay has a small delay from the time the control circuit is closed, or opened, until the time the contacts make or break. Two factors cause this lag; electrical delay in the coil, and the mechanical delay in the moving parts. The total time, usually a few milliseconds, can be varied slightly and accurately by copper rings or slugs built into the core of the coil. Relays of this type are used where several must operate in a definite sequence, yet the total elapsed time must be short.

Relays can be designed with delays of several seconds or minutes. Their delay is caused by a mechanical retarder on the armature or by an auxiliary control circuit that incorporates a timing device. The mechanical retarders usually consist of a piston moving in an air or oil chamber in much the same way as door closers. Small electric clock motors and bi-metal thermostats heated by the control current are typical timers used in auxiliary control circuits.

The use of electronics under adverse conditions of vibration, shock, dust, humidity and atmospheric pressure — with the demand for low failure rate — has led to the development of hermetically sealed relays, which are often used in mobile and airborne equipment, conforming to rigid military specifications.

The method of mounting the relay and connecting the terminals, ranges from the use of mounting studs with solder connections, to plug-in units. The plug-in units permit fast replacement of defective relays where equipment must be serviced quickly. They are also adaptable for use on automatic assembly lines.

13: Fuses & Circuit breakers

IF YOU saw an engineer wire down the safety valve on a steam boiler, you would probably head for the nearest exit; he might follow a few minutes later, steam driven. Yet, do you remember that time last winter when you were down in the basement trying to fix the electric heater? When the fuse burned out, maybe you fixed it by slipping a coin in behind! It is the same sort of thing.

Fuses and circuit breakers are safety devices to be used as protection for the operator and his equipment.

The heart of a fuse is a small piece of alloy that melts at a known low temperature. If the current through the fuse exceeds its rated value, the alloy melts and breaks the circuit. Fuses vary in physical size from the large cartridge type for power use, through the familiar screw base household-type fuse to the small glass cartridge fuses used in electronic and instrument circuits. Some fuses are fast acting; others have a time lag to prevent their burning out on small transient overloads. Motors, for instance, are generally fused with a slow burning type to prevent failure of the fuse while the motor is being started, yet offering protection from a sustained overload during operation. Meters, to the contrary, would be damaged by any overload and must be protected with very fast acting fuses.

Where shock and vibration might be encountered, the fuse metal terminates at one end in a spring. This feature counteracts thermal expansion and contraction, preventing breakage of the fuse link through vibration and crystalization.

The fuse is so cheap, light, small and reliable that it will remain an electronics component for a long time. However, certain jobs have been taken over by its first cousin, the circuit breaker. Early models consisted of spring loaded switches with a holding mechanism that kept the contacts closed. If the current exceeded the rated value, then it melted the alloy where part of the mechanism was buried, releasing it and letting the spring open the contacts. After the fault had been cleared and the alloy allowed to cool and harden, the circuit breaker could be reset by hand.

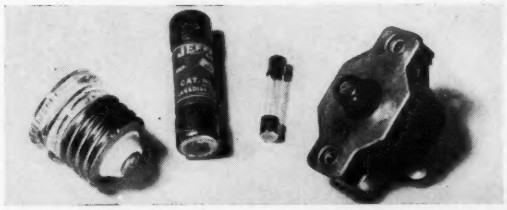
Later models introduced solenoids and modified versions of the relays discussed previously. If the current, either all or part of it flows through the relay coil and exceeds the rated value, it causes the relay to operate and open its contacts.

The breaker is then reset manually unless it is equipped with a second resetting coil.

Manufacturers of electrical apparatus were leaders in the development of recycling breakers, but the electronics industry has been quick to adapt them to the low power field. It was found that many shorts on power lines were of very short duration. Lightning, for instance, used to blow out fuses and cause circuit breakers to open, disrupting service for several minutes at a time. The recycling circuit breakers now in use will open as soon as a fault occurs, then close again in the fraction of a second. If the fault remains the breaker will again open and close.

Depending on design, the breaker will recycle about three to six times before remaining open. If, however, the fault disappears during the recycling period, the breaker will remain closed and the circuit will continue to function. Since this may take only a fraction of a second, the interruption would probably pass unnoticed.

Recycling breakers are being put to work in radio and TV stations where program interruptions are fantastically costly. They are also used in military equipment where failure can result in disaster. This is particularly true in unattended stations and in airborne equipment where the operator is out of reach.



Left to right: Screw-in type fuse; fibre bodied, glass bodied cartridge fuses; and a thermal circuit breaker.

Mass spectrometry fingerprints gases

A dependable and extremely sensitive analytical tool, it analyzes gases, liquids, more quickly than other methods

FIFTEEN YEARS AGO the mass spectrometer was a scientific curiosity. Today it is a dependable and extremely sensitive analytical tool used in research and industry.

The application of mass spectrometry to the fields of industrial development, laboratory analysis and problems in research, has been a major scientific contribution of our time. The outstanding advantage of the method is its ability to analyze gases and liquids more quickly than other methods.

Analyses which formerly took days can now be completed in minutes by the use of automatic mass spectrometry and computation.

Today's mass spectrometer is quite different from the models built by the early experimenters. The early instruments were used to determine isotopic masses and later, the relative abundance of those masses. Today's applications are in quantitative analysis, and commercial mass spectrometers are now designed for that purpose.

A commercial mass spectrometer, suitable for analytical applications, was developed by Consolidated Electrodynamics Corporation, when the firm became interested in analyzing the complex hydrocarbon mixtures encountered in the petroleum industry. A mass spectrometer, developed at the California Institute of Technology, was loaned to Consolidated to facilitate preliminary work. After about four years of research by Dr. Harold W. Washburn and his co-workers, a commercial instrument was placed on the market, the first one being delivered to Atlantic Refining Company in late 1942.

The mass spectrometer works like this from phase to phase:

A sample of the unknown substance is stored in a small container at relatively low pressures, usually in the vapor phase. The molecules are then introduced through a series of special valves called the inlet system. The conglomerate mixture of molecules passes through a restriction called a gold leak (the leak assembly). These tiny openings allow only a limited number of molecules to pass. Next, in the ionization chamber called the Isatron, a much higher vacuum is maintained. Here the molecules are bombarded with a stream of electrons from a heated filament. Some become positively charged ions, others are fragmented and positively charged. The ions formed leave the Isatron chamber through a narrow slit. They are next accelerated to a high velocity by a strong electrostatic field, and pass through a second slit.

Diverting the ions

A magnetic field, parallel to the slits, diverts the fast-moving ions into circular paths, the radius of which is proportional to the mass and velocity of the ion. Thus, the single beam is split into individual beams. Sorted in this manner, ions of a given mass pass through resolving slits and strike a collector 180 degrees away from their starting point. The charges given up to the collector are amplified by an electrometer tube. Having now been translated into an electric signal, the results are amplified and fed to a bank of five galvanometers, each set for a different sensitivity. A tiny beam of light reflected from each galvanometer mirror is photographed on a moving roll of sensitive paper in the recording oscillograph. Thus, the complete mass spectrum is obtained, focusing the separated ion beams successively on the collector by varying the ion-accelerating voltage. As each beam sweeps across the collector, its intensity is recorded on the moving paper.

The various components of the mass spectrometer form several systems and assemblies, as follows:

The sample introduction system provides all the necessary means for admitting gas and liquid samples to the mass spectrometer. Highly polished stainless steel surfaces make sample removal rapid and complete. Integrally contained, packless, stainless steel valves are provided with Teflon valve seats in the system.

What it does

The mass spectrometer works on the principle that every molecule has a particular construction pattern, its individual atoms having a certain geometric arrangement, with bonds of definite strength between them. The manner in which each type of molecule breaks when bombarded by electrons and the quantity of each type of fragment depends on the strength of these atomic bonds. The pattern of breakage and the number of fragments produced is an unmistakable "fingerprint" of each compound.

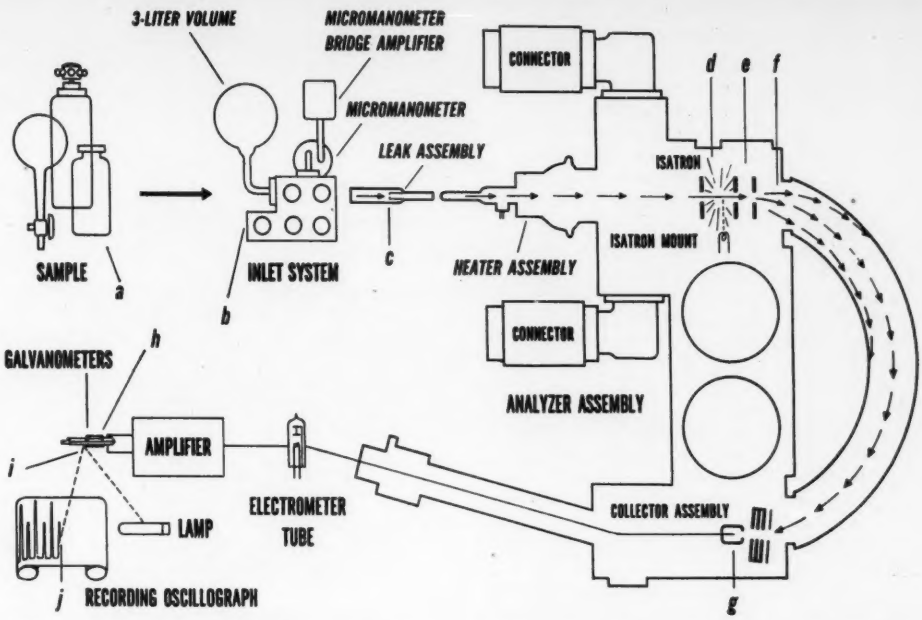
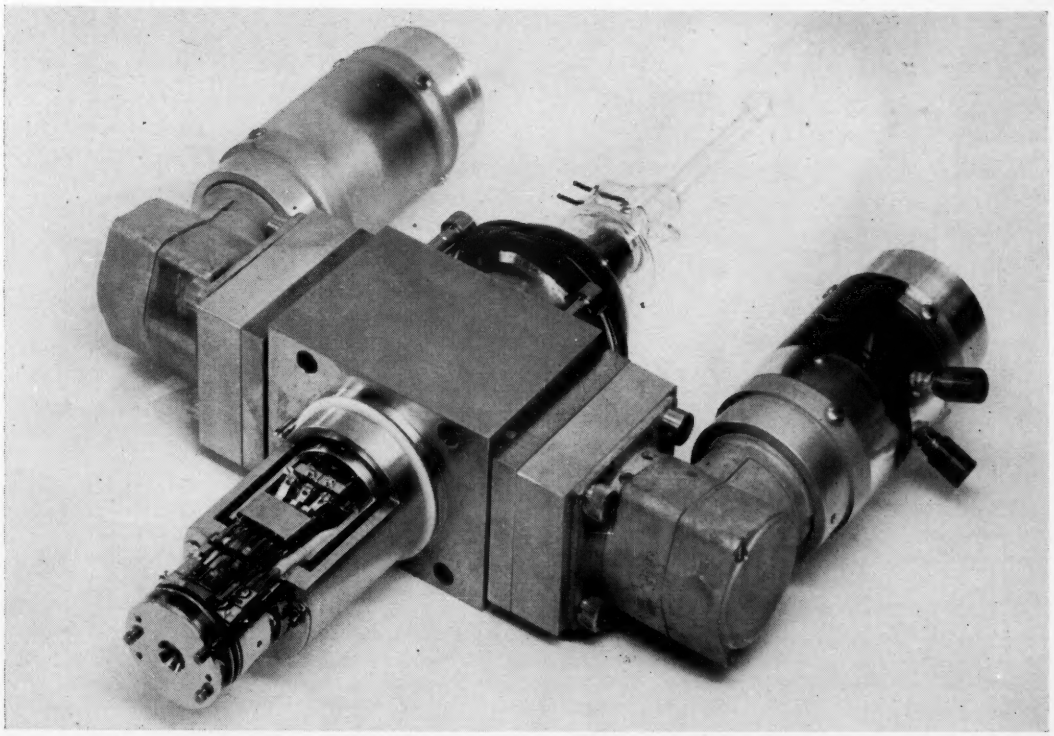


Diagram shows components of mass spectrometer. Phases proceed alphabetically through instrument.

Unknown substance travels tortuous route to record on oscillograph



Isatron is heart of mass spectrometer. Design includes glass, sapphire ball spacers for electrical isolation, positive alignment. They keep parts from shifting with time, temperature cycling, eliminate jigs for isatron's re-assembly.

Fingerprinting gas *(cont.)*

The Micromanometer, a standard component of the inlet system, is a precision-electronic, absolute pressure gauge for measuring sample pressures directly. Its wide range (0.1 to 150 microns) eliminates the usual errors and guesswork of the two-stage expansion method of measurement and provides an automatic check on calculations.

The analyzer assembly. This is a rigid, stainless-steel unit, precision-bored for accurate, reproducible positioning of the Isatron and collector assembly. The 180 degree curvature permits complete immersion of the Isatron and the ion collectors in the magnetic field and eliminates the possibility of ion beam distortions due to magnetic fringes.

There are two individual vacuum systems. One of these removes samples from the sample introduction system, and consists of a mechanical backing pump and an oil diffusion pump. The other is the primary system required for maintenance of low pressure in the analyzer assembly. It consists of a mechanical backing pump, ballast volume, two-stage mercury diffusion pump and two cold traps.

The uniform magnetic field required for segregating the ions is produced by an electromagnet with a 2 in. gap, variable from 800 to 6000 gauss for continuous operation, provides a wide mass range to include a great variety of samples. Note: In the egs system of units, the gauss is the unit of measurement of flux density, that is, the magnetic flux per unit area of a section normal to the direction of flux. The magnet base also provides mounting for the primary vacuum system, and other auxiliary apparatus.

A regulated 4000 volt power supply provides the ion-accelerating voltage and the means of scanning a spectrum.

At fixed levels of accelerating voltage, the mass marker circuit flashes an indicating number on the instrument panel and a mark on the recording. This shows the progress of the scan, and exact identification of mass units on the records.

Complete and automatic protection is provided for the Isatron, and the diffusion pumps against sudden loss of vacuum or loss of power. Thus the instrument may be left ready for instant use although unattended for a long time.

The Isatron control circuit provides completely automatic control of nearly all the voltages and currents used by the Isatron, yet incorporates many manual adjustments needed for over-all flexibility.

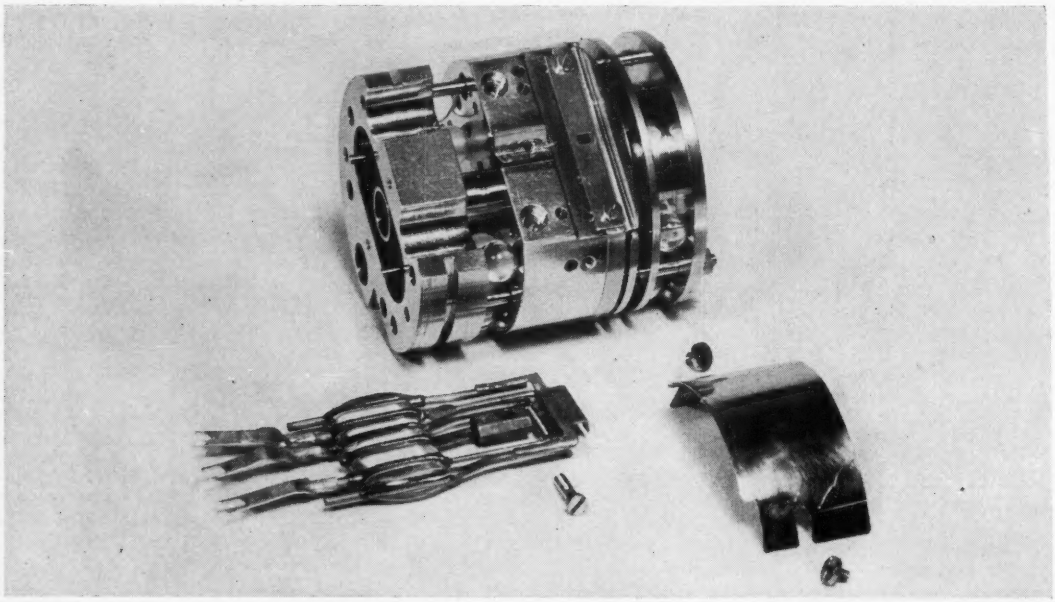
The oscillograph recorder used in the Type 21-103C Mass Spectrometer is the basic component of a recording system which is unsurpassed for speed, accuracy and flexibility. It employs five galvanometers to record simultaneously on photographic paper the amplifier output at five different sensitivity levels.

For example, stainless steel is used in many sections of the mass spectrometer because of its corrosion resistance and its anti-magnetic properties. In several cases, stainless has replaced glass systems, the resulting parts being better aligned, more durable and highly interchangeable. For larger, machined parts the starting point is a billet forged to a specific size.

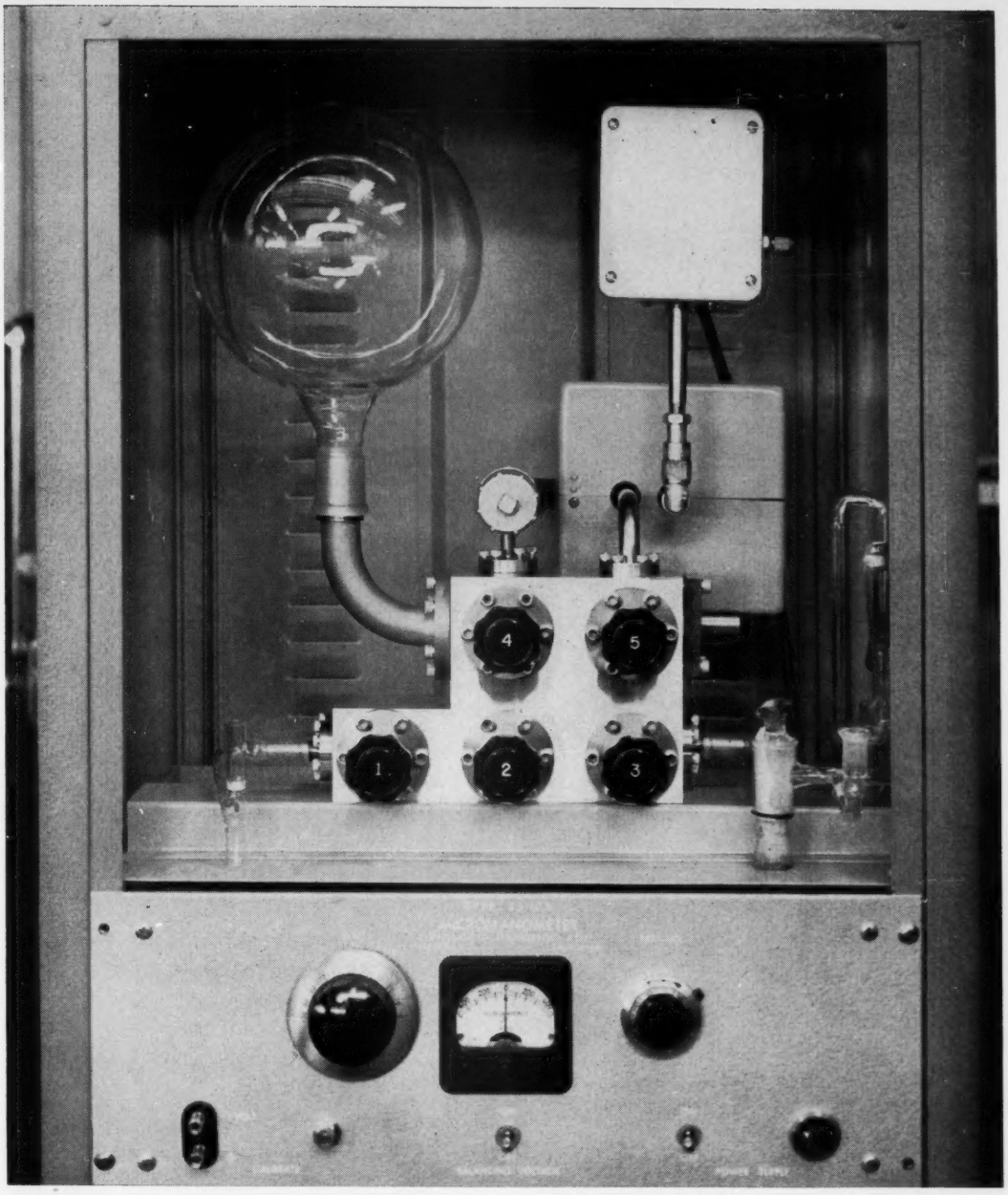
The forging operation produces an extremely low-porosity, dense structure highly desirable for two reasons. First, the possibility of slow leaks through minute fissures in the metal-leaks—that would be of little importance in almost any other type of equipment — is eliminated. Second, with low-porosity, the metal parts do not absorb gases to the extent of ordinary metals, so long pump-out time—that period required to rid the system of all stray gases that might obscure the true analysis or indicate leaks that actually did not exist — is eliminated.

Included among the mass spectrometer's many uses are metallurgy reduction, engine combustion analyses, refinery stream analyses, chemical reaction process monitoring, university chemical and physical research, medical isotope studies, absorption techniques.

An interesting application of the analytical mass



Complete auto control of voltages, currents used by Isatron, element shown removed, is given.



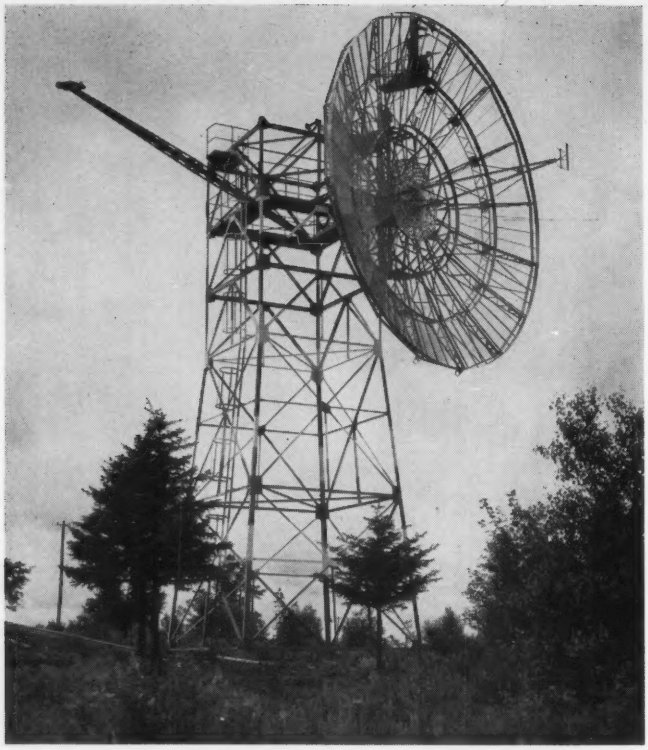
Precision-electronic micromanometer a standard component of the inlet system, measures sample pressure directly.

spectrometer can be found in the laboratories of the Polymer Corporation Ltd., at Sarnia, Ontario, the only integrated synthetic rubber plant in the world today.

The firm's laboratory, with a staff of 130, handles a wide range of research, development and control problems. The mass spectrometer is used for routine control, as well as for special research and development. Control checks include analyses of the fuel gas, the "make" gas from the butylene and ethylbenzene dehydrogenation units, and methyl chloride streams in the butyl plant.

The most dramatic use of the mass spectrometer is in biological and medical research. It is being used by medical schools, hospitals, and medical research institutions. Since 1950, for example, researchers at the University of Wisconsin have been using a mass spectrometer in the study of the mechanism of biological nitrogen fixation. At the Veterans Administration Center in Los Angeles, California, a mass spectrometer is being used to assist in water balance studies and research on human water-metabolism.

Mass spectrometry, an amazing new science which has been made possible through the efforts of design engineers, is not yet publicized outside the engineering and scientific field, yet in one way or another virtually every member of the public is already enjoying some of its comforts and conveniences. ★



This huge UHF antenna at Covey Hill signals 288 miles to Long Island.

Short UHF waves will bend after all

Scientists thought UHF waves moved in straight lines to upper space. Now some are known to follow the earth, making distant transmission possible

LONG RADIO WAVES, such as those used in commercial broadcasting are of very low frequency, measuring about 10 miles between crests. They bend around the surface of the earth and cling to it.

Short waves, called High Frequency, and very short waves, known as Ultra High Frequency behave differently. The short ones, ranging from 33 to 400 ft. from crest to crest dart away from the earth, strike a layer of ionized air at an angle, ricochet to earth, then are reflected up again. As they are successively batted back and forth, they gradually reach their destination.

The UHF radio waves used in transmitting television programs, long distance telephone conversations, and in air navigation systems and radar have yet another peculiar way of traveling.

These very short waves, about 2 ft. in length which scientists believed would refuse to bend with the contour of the earth, have been caught in the same way that a second baseman pulls down a line drive to prevent a ball from zooming to the outfield. Relay towers at 25 mile intervals catch the UHF waves and pass them along to their destination before they can escape.

However, about five years ago, basic research into UHF showed that the signal did not vanish past the 25 miles mark. Though faint, it could be detected and picked up hundreds of miles even from the transmitter. Some of the waves, the scientists reasoned, were not careening off into space, but were acting similarly to a sunbeam when it streams into a room and scatters as it hits dust particles.

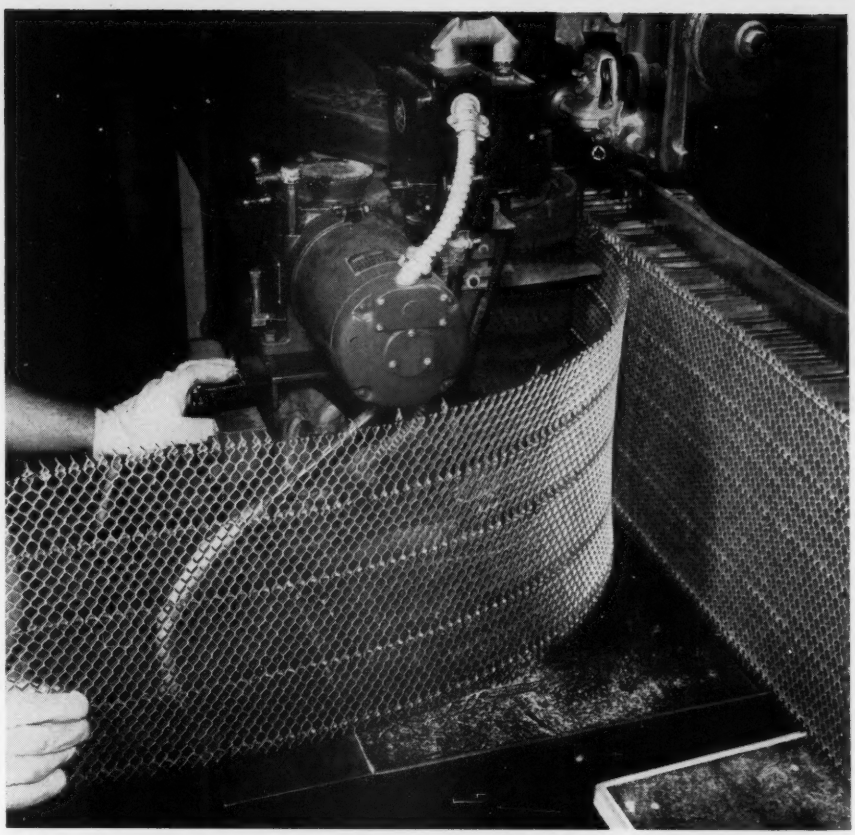
It was further established that the UHF waves were caused to scatter when they collided with globs of air at different temperature and humidity.

From this major discovery participated in by scientists of many organizations, broad new fields opened.

If some of the waves were scattering over the horizon, they could be made stronger if the initial signal were more powerful, they deduced.

"Was it possible then to produce a signal powerful enough to do away with intermediate relay stations?" they queried. If it were, then direct UHF transmission over hundreds of miles was possibly in the offing. Many organizations have been doing research towards this end.

RCA Victor Company *(Continued on page 54)*



Mechanized production of aircomb with honeycomb core sawed to customer specifications.

Use Honeycomb Sandwich In Structures

When prime factors are high-strength, low-weight, economy this pre-cut honeycomb core is an ideal aid to design

By N. A. LOMBARD
DOUGLAS AIRCRAFT COMPANY

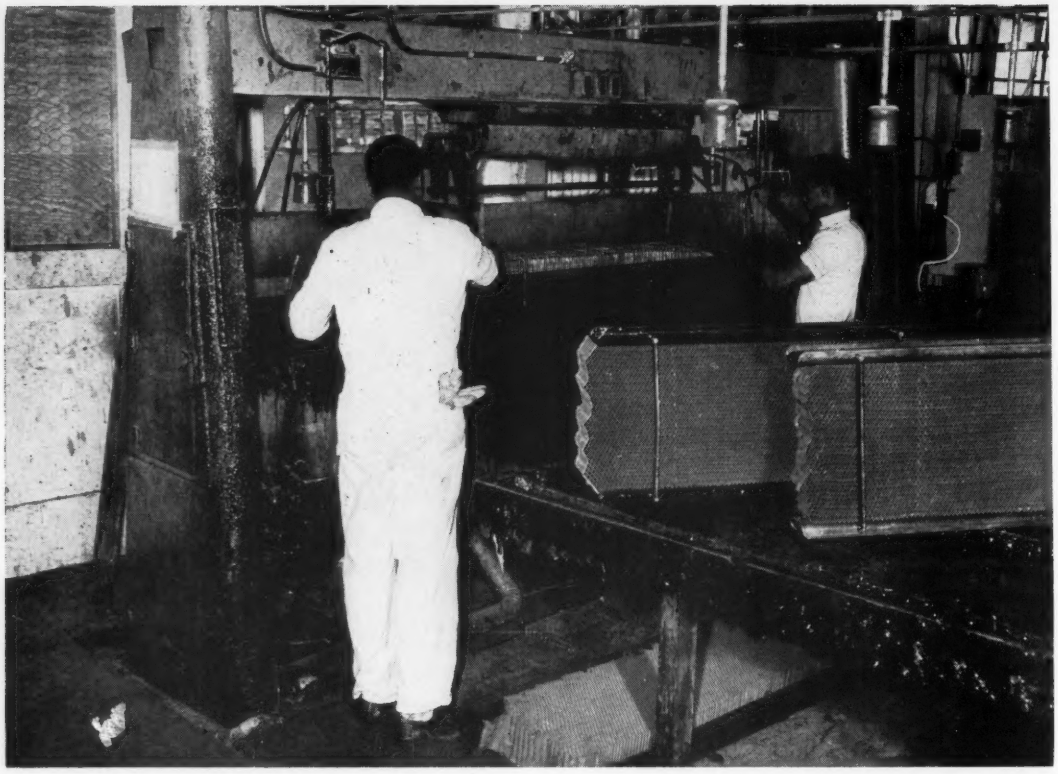
A PHENOLIC KRAFT honeycomb core material known as Aircomb, developed to meet stringent aircraft requirements, is now widely used commercially as a structural material.

It is the result of research and development at Douglas Aircraft Co., for a material combining the qualities of high strength, light weight, integrity and economy. It is used as a sandwich between thin surface sheets of aluminum, stainless steel, magnesium, wood, plywood, plastics and many other materials. The material is shipped pre-cut to close tolerances in any thickness between 1/16 in. and 6 in. and in standard lengths of 108 in., but other lengths are available to special order.

The core is ideal for low-weight, high-strength structural panels because it can carry shear stresses and compression and tension loads normal to the faces of the panels. It keeps the faces of the panel from buckling under loads up to the yield strength of the face material.

Aircomb is not a new product. It was developed in 1946 when tests revealed that products in the field already were not suitable for high rigidity, high strength and low weight uses; consistently high quality was lacking.

As is well known, aircraft parts have to be made to consistent dimensional tolerances found in no other industry. If the sandwich cores built into aircraft parts are not available with this same dimensional stability, they cannot be used. To meet the need, the research program studied core materials, adhesives and resins and then began development that considered production and processing equipment. Aircomb evolved from this research program. Patents covering means and methods of manufacture have been granted and foreign patents are pending at the present time.



The expanded, accordion-folded kraft paper is immersed in a solution until all surfaces of paper are impregnated.

Honeycomb *(continued)*

In the intervening years, hundreds of uses were found in aircraft and in other products for the armed services. On the airplane, for instance, it is used for storage cabinets, partitions, floors and panels, interior doors, baggage racks, all types of tables and cabin ceilings. In addition, use is made of it in guided missile fins, shelters and radar trucks.

While commercial uses of the material are still in their infancy, it has been used for office furniture, flooring, walls, doors, curtain walls, building spandrels. It has been adapted to hundreds of other uses for products that are now made of wood, stone, metal and plastics. Aircomb is believed to be the strongest material in relation to its weight now being manufactured.

Aircomb begins its processing as great rolls of kraft paper. The rolls are threaded through applicating machinery where they get a precision strip coat with resin adhesive. This strip adhesive is placed on both sides of the paper to careful tolerances of 0.001 in.

Beam description	E 10^6 psi	I (b=12)	Rigidity factor EI	Panel thickness (in.)	Weight (lb./sq. ft.)	Beam wt. ratios (aircomb=1)
Aircomb panel	8.0	.099	792,000	1.032	.734	1
Birch plywood	1.25	.634	792,000	.86	3.26	4.45
Aluminum	10.5	.0755	792,000	.422	5.96	8.14
Steel	30.0	.0264	792,000	.296	12.0	16.4

Comparative data on equal rigidity flat rectangular beams: Style 60-20 type 40 aircomb with .016 aluminum faces. E & I are for face material only. E is taken as 0.8 times E value for face material to account for deflections.

The coated paper is quickly dried, cut and stacked accordion-wise and is then bonded in a Peeco heater with di-electric heat.

The bonded, accordion-folded kraft paper is then expanded and precision contained in a magnesium holding fixture which controls the honeycomb dimensions for subsequent processing. The expanded raw stock is immersed in a solution until all surfaces of the paper are thoroughly impregnated.

The equipment involved in this entire processing installation is Douglas designed. The impregnation installation keeps the resin at a constant temperature. Its timed cycle is automatic and at the end of the cycle the expanded material is removed from the bath in its holding fixture and shaken to expel surplus liquid from the honeycomb.

The fixture holding the impregnated core material next goes to an automatic tunnel furnace where in the first 60 ft of travel all fumes from the resin are removed before going through the last 25 ft of the furnace. There the cure is made at 300 deg F. This cycle takes about 60 minutes after which the rigid core is removed from the holding fixture, ready for precision cutting to the desired size.

For fabrication into some parts the material is cut cross-wise with dinking dies of the required configuration. Precision sawing reduces it to the required thicknesses.

The fabrication of panels is typical of all types of installation. The face material for some of these panels for military use is aluminum sheet 8 ft by 12 ft. This is first cleaned and etched and then sprayed (after drying) with a top grade adhesive. The honeycomb is sandwiched between the adhesive coated faces and put in a steam-heated bonding press. This 250-ton press has a bed that will take panels up to 10 ft by 20 ft. After the curing cycle the panels become structural parts for special installations.

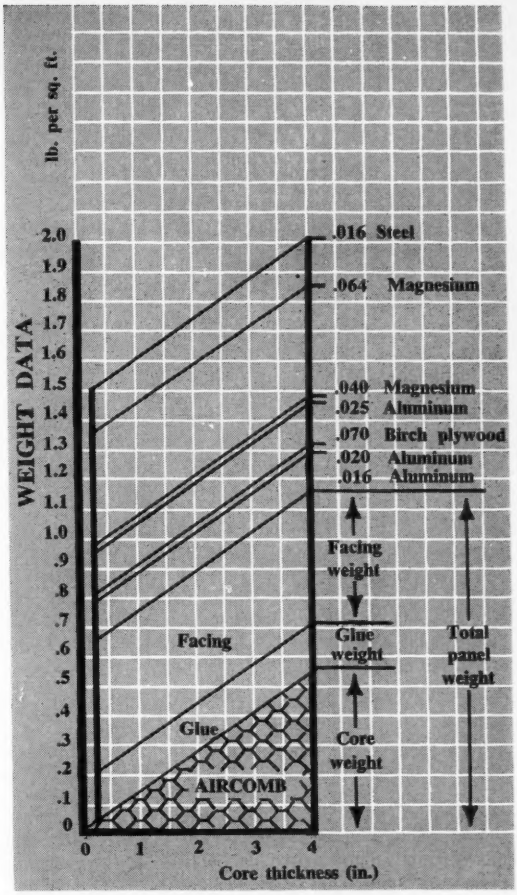
They are extremely rigid. One inch thick Aircomb faced with 0.016 in. aluminum has an EI or rigidity factor of 792,000 and weighs 0.75 lb per sq ft. This compares with other structures of the same rigidity as follows: 1/16 the weight of steel, 1/10 the weight of aluminum, 1/5 the weight of birch plywood.

A 3 in. thick panel faced with 0.020 aluminum has a thermal conductivity value of U=0.210. Btu/hr/sq ft deg F. difference. This resistance compares to other structural materials roughly as follows: Twice as good as 8 in. thick brick wall, twice as good as 12 in. thick concrete, twice as good as double strength glass windows, 30% better than typical residence frame wall construction of stucco outside and metal lath and plaster inside.

Insurance companies have indicated that rates on structures of honeycomb panel construction will be lower than present rates for structures of a like construction because the new panels will not burn. Tests made in a leading wood-products laboratory show that Aircomb is superior in durability to comparable structural materials.

It is above average in its resistance to attacks by pests and by special treatment can be made completelv resistant. Its effective usable range is from —65 deg F to +450 deg F.

The Douglas Company will only be manufacturing Aircomb items which are necessary for their own industry. Otherwise, Aircomb is being sold in bulk lots to any manufacturers who want to use the material for their products. To assist these companies, Douglas is prepared to engineer and build prototype items. ★



Above, the graph shows weight data for panels using style 60-20, type 40 aircomb with various face materials.

Fabricated by sandwiching core material between adhesive coated faces, honeycomb panels are stacked.

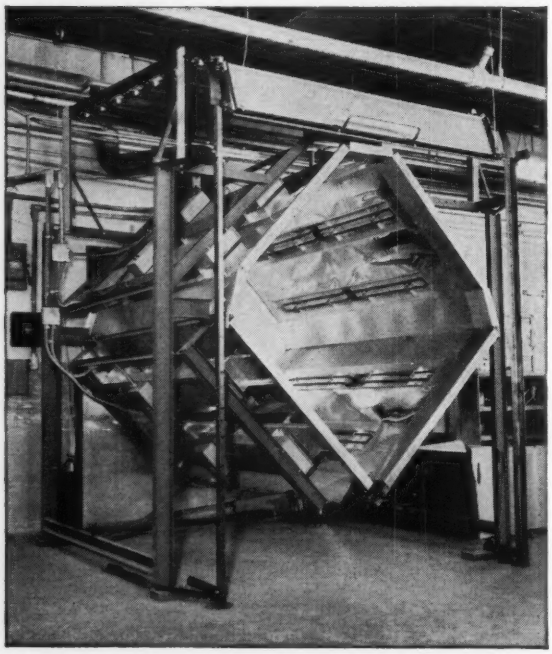
HOWARD S. LITCHFIELD, Vice-President in charge of design and plant operation for Air Coils Mfg. Co. Ltd., Oakville, Ontario.

"We Cut Enamel minutes with our

Air Coils Mfg. Co. Ltd. report faster production, lower operating and maintenance costs on baked enamel finishes using G-E Calrod Oven in producing equipment for refrigeration, air conditioning, heating and cooling industry...

"G-E Infra-Red Radiant Calrod Ovens cut our enamel finishing operation from 30 to 7 minutes per unit, and reduced the fire and explosion hazard present with the process previously used", says Howard S. Litchfield, Vice-President in charge of design and plant operation, Air Coils Mfg. Co. Ltd., Oakville, Ontario.

"The economies and flexibility of the G-E Calrod Oven make it more economical in many ways," Mr. Litchfield claims. "In addition to faster baking time, and with heat losses eliminated we have greater control of oven heat at all times... we have eliminated over and under-baking of enamels. Greater oven control also lowers our operating costs. The oven can be shut off until the material is ready

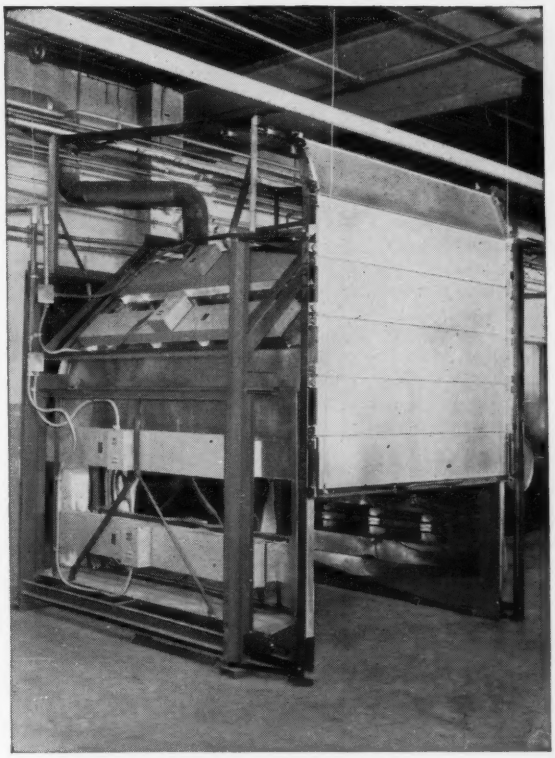


Interior of the G-E Infra-Red Radiant Calrod Oven used by Air Coils Manufacturing Co. Ltd. The main body of the panels is insulated with fiberglas, and reflectors made of highly reflective aluminum sheet reduce heat losses. The Radiant Calrod Elements are sheathed with special stainless steel for long life under severe conditions. These plug-in elements also resist dropping liquids, paint, etc., and are easily removed. Panels are fitted with two Calrod units, each 3, 4 or 5 KW for panel wattages of 6, 8 or 10 KW; voltages 230, 460 and 575. Units CSA approved.

CANADIAN GENERAL ELECTRIC

Finishing Time from 30 to 7 G-E Radiant Calrod Oven"

Side view of the same G-E Calrod Oven illustrating its versatile flexibility. Because of its simple, low-cost frame-work design, and the fact that no expensive insulation is needed, the oven can be quickly disassembled and reassembled to suit changes in product design. These ovens can also be suspended from the ceiling to save valuable floor space and are adaptable to any conveyor system. Plug-in Calrod Elements are interchangeable for higher or lower wattages. Terminal box is located on back for easier wiring, and mounting holes on panel permit easy assembly.



—it is not necessary to operate it continually to assure a steady flow of production.

"Explosion hazards are eliminated too—an adequate forced air exhaust system is applied without affecting the baking process. Workmen are safer and the material is easier to handle since the heat is dissipated before material leaves the oven.

"Flexibility is another factor in favour of the G-E Calrod Oven," he says. "Our production pieces vary in size. With careful planning we can take advantage of the flexibility of this unit to get the most efficient finishing of all our products regardless of size or shape."

For complete information on G-E Infra-Red Radiant Calrod Ovens and Panels, contact your nearest C-G-E office, or fill out and mail the attached coupon . . . today!

INFRA-RED RADIANT Calrod Panels

COMPANY LIMITED

Component Heating Devices Sales 436W-955
Canadian General Electric Co. Ltd.
224 Wallace St., Toronto, Ont.

Please send further information on G-E Infra-Red Radiant Oven and Panels to:

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Quotes

Points from current papers and speeches

THE SUBJECT OF modern high voltage rubber insulations was discussed by **W. H. Couch, G. H. Hunt, N. D. Kenney** and **P. H. Ware** at the Fall Meeting of the AIEE.

One of the earliest rubber insulating compounds developed in this country was the so-called oil-base type. Cables insulated with natural rubber oil-base compounds were installed for communication and other low voltage services in the 1860s. There is no standard definition of an oil-base compound.

In general, however, it contains various vulcanized vegetable oils, bitumens, reclaimed rubbers, and either natural or (GR-S) synthetic rubbers. Of course, these compounds also contain other chemicals for vulcanization, resistance to oxidation and other desired properties.

Although oil-base rubber power cables are used for many types of service, cable engineers for years have recognized the need for a rubber insulation with operating characteristics not obtainable with that type of rubber compound.

The development of synthetic rubbers in recent years has provided a material which, when properly used in a rubber compound, results in an insulation having greater resistance to deterioration from heat, aging, ozone and moisture than was previously available.

This synthetic rubber is butyl, described by the chemist as a hydrocarbon with a much lower degree of unsaturation than either natural rubber or GR-S synthetic rubber. Since the tendency to oxidize and deteriorate from ozone decreases with the lowering of the unsaturation, the saturated bonds of butyl permits the compounding of a rubber insulation having better aging properties, greater resistance to heat and lower susceptibility to ozone than is possible with other rubber insulating compounds. The moisture resistant properties have also been improved.

• • •

THE CASE OF the moaning stack is the title of an article in **CEC Recordings** for July-August 1955.

Tiny pressure pickups measuring pulse pressures on a 140-foot exhaust stack provided information which led to the correction of a serious sound-level problem for Standard Oil of California. Residents near the company's El Segundo refinery and employees in the refinery itself had complained of plant operation noise. **Fluor Corporation** engineers, well known in the sound-vibration field, were called in to locate the trouble and eliminate the source. They discovered that the exhaust stack on a catalytic cracking unit was resonating as an open-end organ pipe.

The physical phenomenon of "resonance" is one reason why we enjoy music. However, this characteristic, which makes a pipe organ (essentially a collection of open-end pipes) a magnificent musical instrument, can have devastating effects in an industrial plant.

The driving energy necessary to excite and maintain resonance was being supplied by a gas burner at the foot of the stack. The rate of burning of the gas, the gas-piping configuration and the particular design of burner head used were such that a small pulse was generated at a frequency very close to one of the stack harmonics.

Resonance of an open-end pipe may be explained as follows: Waves will be reflected at any point where a major cross-sectional change of area occurs, such as at the exit of the stack. These waves then travel back down the pipe, and, when they are reflected at the opposite end of the pipe in phase with a pulse generated at this point, they are amplified.

The pickups were placed at the end of 6-in. fin-tube section plugged into ½-in. holes bored through the steel shell and refractory-cement lining of the stack. The fin-tube sections were necessary to dissipate the gas heat which reached some 800 deg F. Measurements were made with the pickups at six-foot intervals to a height of 60 feet on the stack.

Fluor engineers found that the stack was resonating at a low-frequency pulse rate of 33-41 cycles per second. The sound level measured at the base of the stack was 116 db. This explained why the sound vibrations were being heard half a mile from the plant.

By plotting the pressure-wave values from an oscillogram, the wave pattern was clearly evident, with the highest pressure occurring at the antinode or crest of the vibration wave, and the lowest at the node.

After suggesting deresonating holes at the antinodes to prevent pulse-wave build-up, the engineers found that minor fuel/air-ratio changes controlled the resonance.

• • •

AN SAE PAPER, "Report on Suspensions for Commercial Vehicles" by **Maurice Olley** was the outcome of his assignment to report on three earlier papers dealing with air and heavy vehicle suspensions, self-leveling torsilastic suspension and liquid springs in vehicle suspensions.

Vehicle suspensions so far known or contemplated have been of four types; metal springs; pneumatic suspension; rubber suspension; and liquid springs, in which the compressibility of fluids is used as the spring.

In addition we ought to consider leveling devices, which work to maintain a reasonably constant standing height regardless of the load on the vehicle.

As regards pneumatic suspension — metal springing was not dealt with — the typical Firestone Air Spring is made like a nylon cord tire, with two layers of nylon fabric, rubber coated inside and out.

The really important thing is that, with ordinary springing, as the load increases the frequency comes down, and at light loads it is very fast. But, with the air bellows the frequency is about the same at all loads. Since freight vehicles often travel partly laden, this feature is important to the driver and also to the cargo.

The final result is a suspension, which has highly desirable rate characteristics, has proved almost indestructible, and which is numbered in the thousands.

In rubber suspension we have an entirely different method of suspension, which has also received wide application both on commercial and military vehicles.

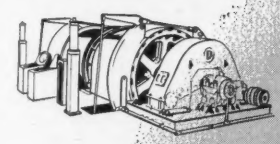
Each suspension unit in the Goodrich Torsilastic system is in the form of a very large rubber bushing of which the inner or outer portion is held to the vehicle or axle, while the other portion carries the suspension arms.

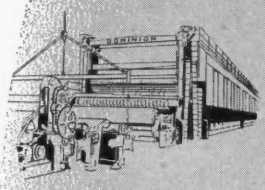
Suspension by rubber in shear has been in limited production for many years. Early difficulties, that the standing height tends to vary with atmospheric temperature and that there is considerable initial creep when the bushings are first loaded, have been largely overcome. In any case, these effects are washed out when automatic leveling is used.

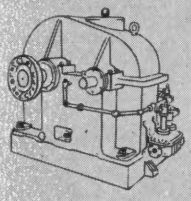
Lately, inter-city coaches have tended to increase in over-all height up to and even beyond the height of the old double-deckers; hence an increased necessity to consider the rolling tendency on corners.

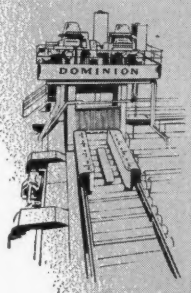
Liquid springs are an entirely different sort of development. Only some very preliminary and tentative application to vehicle suspension appears to have been made. But in other fields there has been wide application, and we in the vehicle industry cannot afford to pass up anything which looks so promising.

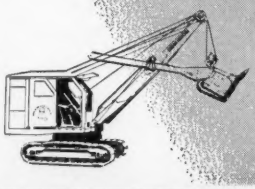
It is based on the fact that, regardless of what we were taught in our youth, liquids are compressible. Some suitable modern fluids compressible by as much as 12% of their volume under 20,000 lb pressure. There is no need to balk at such pressures, since they are now quite commonly used. Such a pressure will carry a 10,000-lb load on the end of a rod of 11/16 inch diameter.



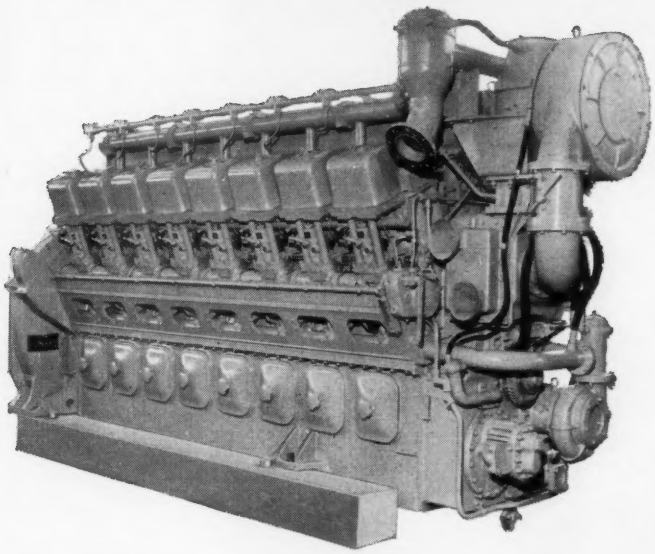








For Reliable Power choose DOMINION diesel engines



Wherever Diesel engines are required, whether for general or specific applications, Dominion Engineering has the engines best suited to *your* particular purpose. Dominion "Alco" Diesels are rated from 500 B.H.P. to 2400 B.H.P., have been used for marine, industrial, mining, pipeline, locomotive and many other applications. Because they are built and serviced in Canada, maintenance and parts problems are held at a money saving minimum.

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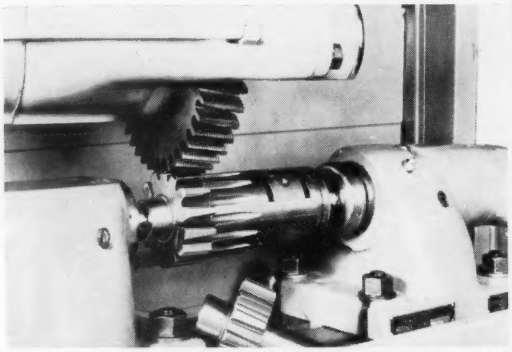
Design news in pictures

Some modern designs making news today

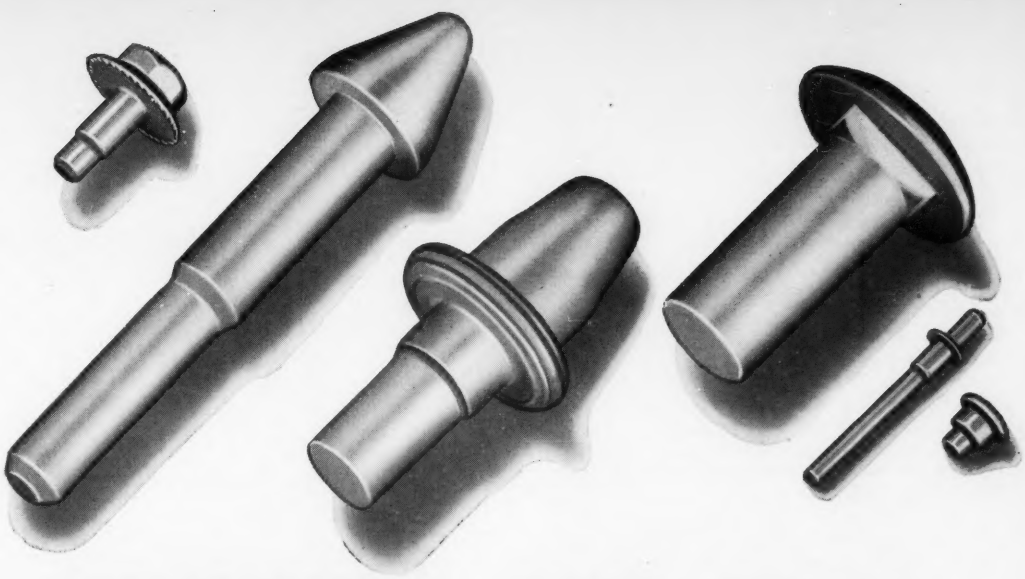
Sleek, ten-coach, 400-passenger General Motors Aerotrain weighing 50 per cent less than conventional trains, was designed for G.M.'s Powerama, is considered to be answer for helping to pull passenger traffic by rail out of red.



New rotary gear shaver by National Broach and Machine Co. shaves conical tapered-tooth gears. Segment to be shaven is mounted in an arbor assembly having steel dummy teeth which complete tooth circumference of gear segment.

The magnetron tube which the technician is adjusting in Tappan Stove Company's revolutionary electronic range, already in production, transmits microwaves which cook food. Microwave unit is made by Raytheon Manufacturing.

Ingenious Ryan Car-Stir designed and made in England is cramped space aid. Rear Wheels are driven onto ramps between castors, engine is switched off and handbrake applied, then car is simply pushed out of tight squeeze.

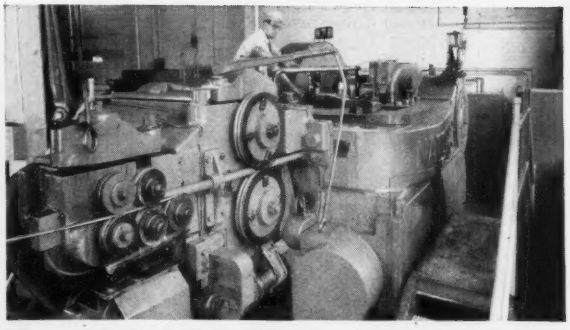


KNOCKED OUT COLD . . .

BY

STELCO

WITH TWO BLOWS



This COLD HEADER transforms wire into upset parts

RAPIDLY, CHEAPLY, WITHOUT WASTE!

The economy, speed, and versatility of Stelco's Cold Heading equipment offers wide possibilities for savings in contoured and specially shaped parts.

The examples shown above are ordinary every-day ones . . . yet they show savings in metal costs alone of as much as 63.5% in comparison with similar parts produced by machining. In addition, they are produced by Stelco at rates from 60 to 250 per minute, against a maximum of about 40 per minute for automatic screw machines.

On Stelco's Cold Headers, wire up to 1" in diameter, of any forgeable metal, can be upset to 4½ times its original diameter, with secondary operations such as threading, punching, shaving, or bending being added if desired.

Stelco Engineers will be glad to advise on the adaptability of cold heading to *your* needs. Address your enquiries to any Stelco Sales Office.

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Waves will bend

(Continued from page 44)

Ltd., has developed a giant UHF tower and antenna, the "Wavestack" which has been erected at Covey Hill, Quebec.

Standing atop the most northerly peak of the Adirondacks on an 1,100 ft. elevation, it combines a huge antenna with a sharply stepped-up supply of electric power that drives a super strong UHF signal. The antenna which transmits at 468 megacycles is one of the largest of its type in Canada. Built in the shape of a parabola, it is 40 ft. in diameter, mounted on a steel frame tower 50 ft. high. It was named Wavestack because of its resemblance to a factory smokestack by Bruce MacKimmie, a young company engineer who worked out its theory. He is in charge of the project in Canada. Henry Buzzel of Dominion Bridge Co., did the mechanical design and the company also erected it for RCA Victor.

The large antenna has stood in the quiet farm country of Huntingdon County for two years and yet few people knew its origin or purpose.

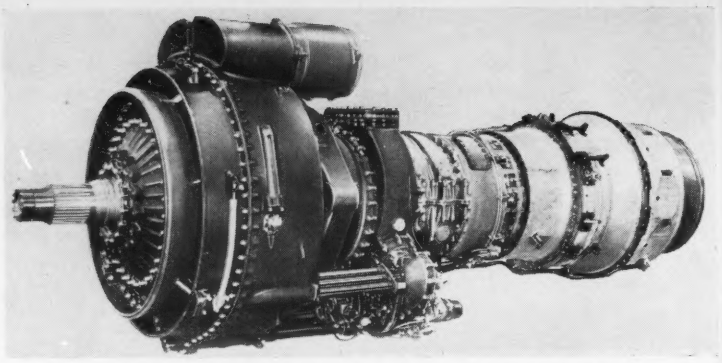
In late August of 1955, the device was successful in transmitting UHF signals from Covey Hill south-west across the Adirondacks and the Green Mountains to Long Island, N.Y., 288 miles away without relay stations. Now the circuit is in steady use as the project beams the UHF waves in different ways, studies the results and applies them to the design of new and better communication systems.

Short wave radio, sometimes out of commission for days due to changes in the layer of ionized air, not only transmits voices poorly but is always subject to fading. UHF is more dependable than short wave and is ideal for voice transmission.

The cost of an antenna like the one at Covey Hill is much higher than the smaller kind needed in most of today's UHF communication and much more power is used. In spite of this company experts say extras costs are negligible compared with the potential savings from the elimination of relay stations.

Spanning forest and jungles, spearing through mountain ranges, linking key points along desolate northern frontiers; in places like these where the cost of a relay station every 25 miles is prohibitive, the Wavestack may eventually solve communication problems.

In the meantime, UHF experiments at Covey Hill continue as the strange bowl-shaped antenna acts as the pitcher in a giant game of international catch that extends 300 miles to the Atlantic shore. ★



Schedule in freighters is outlook for Tyne that has already made initial runs.

Rolls-Royce Tyne is newest prop-jet

EARLIER standards set by the Rolls-Royce "Dart" can be expected to be upheld in a new propeller turbine engine produced by the company, the R.B. 109, or "Tyne" as it has been recently named.

The Dart as predecessor achieved a high reputation for reliability, starting with an overhaul life of 400 hours which was increased in less than two years to 1,050 hours.

However, in a survey of the trend of operator's requirements for new aircraft it became clear that the new generation of airliners would be larger and would have to be capable of flying in excess of 400 mph.

These considerations indicated the need for a propeller turbine engine having a design power greater than the limit of power development in the Dart.

In 1953, the company began the design of the R.B. 109 using the mechanical and aerodynamic experience gained from current gas turbine engines. The design stage was followed by extensive rig testing of individual assemblies before a complete engine was built. Three experimental engines have been completed and are now on test. The first made its initial run in the spring of 1955.

The first flight trials of the engine will be made early this year in a "lincoln" testbed.

The company regards scheduled operational flying as an essential part of the development of an engine for airline service. In the case of the Dart, four engines were installed in two Dakota aircraft and completed 4,000 hours on scheduled operation. With the Tyne the company intends to follow the same flying-testing routine by installing the new engines in Ambassador aircraft which will be put into scheduled service, possibly as freighters.

The Tyne has been designed around a 12 to 1 pressure ratio, two-shaft, axial flow compressor, giving a high pressure ratio for good economy at cruising conditions.

Civil aircraft must use high compression ratios in the larger sizes for the same reason that heavy road vehicles have switched to the high compression ratio diesel engine in order to save fuel.

Fuel economy and power are also improved in the R.B. 109 by increasing flame temperature for take-off and cruising without impairing the overhaul life of the engine.

The high-pressure compressor is driven by its own turbine and the low compressor and the propeller are driven by a separate turbine, the shaft of which runs inside the high-pressure shaft.

The propeller is coupled to the low-pressure shaft through a compound epicyclic reduction gear, the internal mounting of which has been designed to damp out vibration, improving engine reliability and passenger comfort.

A single throttle lever interconnected with the propeller controller controls the engine. An automatic temperature control maintains the correct relationship between power and propeller speed for take-off from aerodromes at different altitudes and temperatures.

The Tyne is equipped with reverse pitch propellers to provide the braking that is now a standard feature of transport aircraft. ★

PATENTS AND DESIGN REGISTRATIONS

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Patent and Trade-Mark Attorneys
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5 pipe sizes, ¼" to 1" incl. Replaceable, transparent oil reservoir. Series 30-41-LC.

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Model 30-41-2S—¼" pipe size. 32 bearing inch capacity.

1¾ GAL. OIL CAPACITY

Model X3400-2S—¼" pipe size. 32 bearing inch capacity.

Model X3400-6S—¾" pipe size. 200 bearing inch capacity.

Model X3400-8S—1" pipe size. 300 bearing inch capacity.

4½ GAL. OIL CAPACITY

Model Y3400-2S—¼" pipe size. 32 bearing inch capacity.

Model Y3400-6S—¾" pipe size. 200 bearing inch capacity.

Model Y3400-8S—1" pipe size. 300 bearing inch capacity.

Model 33AB-4

½" Inlet, 2" Outlets. 1000 bearing inch capacity.

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3 OZ. OIL CAPACITY

¼" pipe size. Permanent, metal oil reservoir. Model 399LB-2.

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1 QT. OIL CAPACITY

5 pipe sizes, ¼" to 1" inclusive. Replaceable, metal oil reservoir. Reversible. Series S406.

1¼" and 1½" pipe sizes. Permanent, metal oil reservoir. Series 406.

2 QT. OIL CAPACITY

5 pipe sizes, ½" to 1½" inclusive. Permanent, metal oil reservoir. Series 408.

2 GAL. OIL CAPACITY

5 pipe sizes, ¼" to 1" inclusive. Replaceable, metal oil reservoir. Reversible. Series X400 and X402.

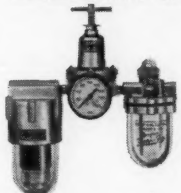
1¼" and 1½" pipe sizes. Replaceable, metal oil reservoir. Series X406.

5 GAL. OIL CAPACITY

5 pipe sizes, ¼" to 1" inclusive. Replaceable, metal oil reservoir. Reversible. Series Y400 and Y402.

1¼" and 1½" pipe sizes. Replaceable, metal oil reservoir. Series Y408.

LUBRO-CONTROL UNIT



showing typical combination of Micro-Fog Lubricator with Automatic-Drain Filter and Air-Pressure Regulator.

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AIR LINE FILTERS • PRESSURE REGULATORS • LUBRICATORS • AIR CONTROL VALVES

Patents

Some new ideas win protection in Canada

THE TENDENCY OF tire treads to crack in the grooved parts of the tread is the problem dealt with by Canadian patents Nos. 516,271 and 516,272, issued to Dominion Rubber Company Limited of Montreal on September 6, 1955.

No. 516,271 describes a method of treating a tire by applying a heat-protective coating to the surface of the tread near the grooves, flexing the tread by applying pressure to the sides, thus stretching the rubber at the bottom of the grooves, and applying radiant heat to the grooves during the stretching, to soften the rubber. After cooling the softened rubber, the tread is released so that the rubber at the bottom of the grooves is placed under compression.

Instead of using a heat protective coating, the tread near the grooves is water cooled while the tread grooves are being heated.

The inventors are William F. R. Briscoe and Robert B. Plummer of Detroit, Michigan.

• • •

N. V. PHILIPS Gloeilampenfabrieken has patented a method of electric arc welding in which the arc is struck directly between the pieces to be joined by using a semi-conducting block to space them apart. The block is conductive enough to initiate the arc, and separates the pieces just long enough to prepare the pieces for proper welding.

The pieces are spring-pressed against the block so that they come together as soon as the semi-conducting block is melted by the arc. This completes the joint and short-circuits the arc curent, which is then switched off.

Invented by Paul C. van der Willigen of Eindhoven, Holland, this method is covered by Canadian Patent No. 512,976 issued May 17, 1955.

• • •

A NEW LEAK resistant dry cell with a specially designed closure is covered by Canadian Patent 514,388, which issued on July 5 to Olin Mathieson Chemical Corporation of Saltville, Virginia.

Invented by Otto R. Reinhardt of West Haven, Connecticut and J. Y. Welsh of Brainerd, Minnesota, the closure is a shaped disc with a central opening for the cathode. A depending collar surrounds the opening, and another is arranged just inside the outer edge. A washer rests on top of the material in the cell, and is coated with a thermoplastic sealing composition. On this rests the disc, with the collars embedded in the composition.

The collars are shaped so as to force the softened composition against the outer wall of the cell on one side and against the cathode on the other, thus making a tight seal.

• • •

A NEW CABLE with cellular polyethylene insulation, for conducting high frequency electric current, has been patented in Canada by Anaconda Wire and Cable Company of New York. Invented by Lawrence C. Ebel of Dobbs Ferry, New York, and Ralph G. D'Ascoli of Yonkers, the cable has the conductor embedded in the flexible monolithic mass of cellular insulation. The polyethylene has a smooth non-porous outer skin and each of its individual cells is separated from the others by impervious walls of the plastic, thus making the structure moisture-proof.

The cellular polyethylene has a bulk density that is 40% less than that of solid polyethylene and it has superior high frequency dielectric properties.

The cable is covered by Canadian Patent No. 516,068 issued August 30, of last year.

• • •

"CATALYTIC PLUGS" for preventing detonation and knocking, and giving more efficient use of fuel in internal combustion engines, are claimed in Canadian Patent 517,398 issued Oct. 11, 1955 to Oxy-Catalyst, Inc., of Wayne, Pennsylvania. The plugs have ceramic slides in their ends, coated with a base film of alumina or the like which is impregnated with an oxidation catalyst like platinum, silver, or copper. They project into the combustion chamber and they can be inserted by substituting a new cylinder head threaded to receive the catalytic plugs as well as the usual spark plugs.

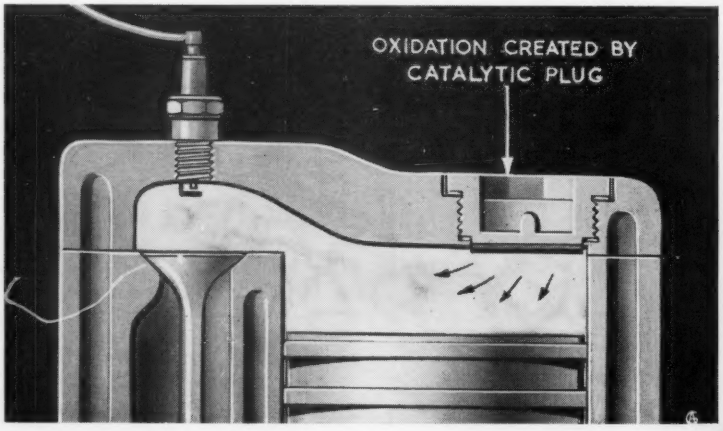
According to the inventor, Eugene J. Houdry, of Ardmore, Pennsylvania, the effect of the catalytic material is to give engine performance with low octane fuel that equals or exceeds normal performance with higher octane fuels. They also give what amounts to an increase in compression ratio by promoting flameless oxidation of part of the fuel, and carbon deposits are eliminated.

• • •

A NEW METHOD of welding, based on the idea of filling the space between the edges to be welded with hydrogen gas under pressure on the face opposite to the one that is being welded, is covered by Canadian Patent No. 516,119, issued August 30, 1955, to I-T-E Circuit Breaker Company of Philadelphia.

• • •

THE WESTERN Union Telegraph Company of New York has obtained Canadian Patent 516,180 on a message transmitting blank for facsimile messages. It has a base sheet with a conductive surface, arranged to be scanned by the electrical stylus of a facsimile transmitter. Impressed on the surface of the sheet are message characters composed of an insulating composition that adheres to the conducting surface. When the sheet is made conductive, the current in the stylus circuit is interrupted when the stylus passes over the insulated areas formed by the message characters.

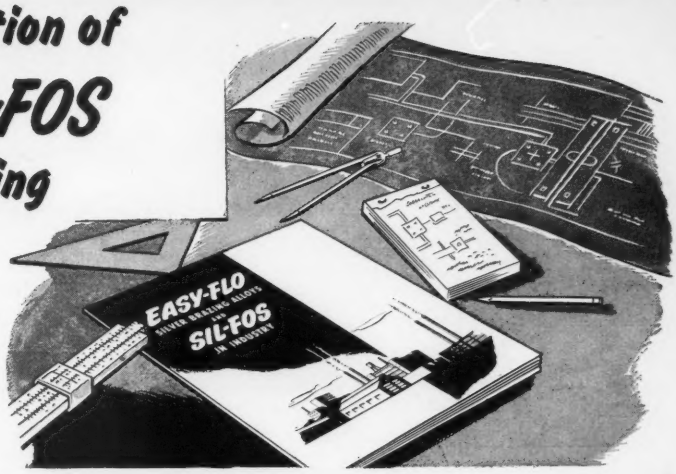


PRODUCT IMPROVEMENT

Starts with Specification of

EASY-FLO & SIL-FOS

Silver Alloy Brazing



Regardless of the type of metal assembly proposed—a simple torch operation or a large scale mass production job —one of the EASY-FLO Silver Brazing Alloys or SIL-FOS may do it better.

Available in compositions for many uses, EASY-FLO or SIL-FOS Silver Alloy Brazing is proving there's no end to the jobs they can do in speeding production . . . cutting costs . . . improving product quality. The EASY-FLO and SIL-FOS story — including technical data — is yours for the asking. Write us, today.

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The technical and practical assistance described below, is immediately available, without cost or obligation to any user of EASY-FLO or SIL-FOS Silver Brazing Alloys through our engineering and research departments, field service staff or nearest dealer.

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SURVEYS
of your metal assemblies to determine if and where EASY-FLO or SIL-FOS Silver Alloy Brazing can benefit you.

PRODUCTION AID
to help work out the procedure that will give you the desired output at lowest cost.

DESIGN AID
for your engineers to assure best joint design for EASY-FLO or SIL-FOS Silver Alloy Brazing.

OPERATOR TRAINING
of your Key men in our brazing school or by a program we set up in your plant.

RESEARCH
in our laboratories to work out your special silver alloy brazing problems.

Bulletin C20 contains the full facts about EASY-FLO and SIL-FOS. It tells why these alloys are being used in such large quantities throughout all industry. It also includes useful information about joint design and fast brazing production methods. Write for your FREE copy today.

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A GAS FIRED oven designed and built to meet industry's need for an oven with adjustable temperature control from 100 deg F to 1,000 deg F has been produced by **Grieve-Hendry Co., Inc.**

Because of its wide range of temperature adjustment, it has been found suited to operations like burning off old insulation on electric motors, and baking on new varnish after rewiring.

Construction of the oven is all steel designed as a cabinet within a cabinet with five in. of Rockwool insulation.

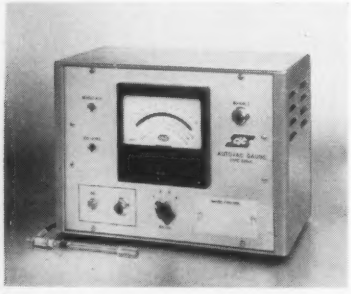
Gas burners at the bottom of the oven supply the heat and a heavy-duty grate is built in over the heating system. A Partlow temperature controller is included.

The drip pan of the oven is removeable from the oven exterior and may be taken out for cleaning while the oven is being used. (200)

• • •

A NEW one-to-four-station vacuum gauge which gives continuous pressure readings from 100 millimeters Hg to 1 micron (.001 millimeters) Hg is being distributed by Consolidated Vacuum Corporation.

Made by **LKB-Produkter,** Sweden, the Autovac as it is known provides a higher



A new vacuum gauge

degree of calibration stability, it is reported, than any other instrument of its type. Applications for the versatile gauge include vacuum furnaces, stills, metallizers, dehydration units, and other processing equipment.

An outstanding feature of the instrument is its automatic switching from the millimeter range (100 to 0.1 mm Hg) to the micron range (100 to 1 micron Hg), with a special range-selection circuit. A red pilot lamp indicates when the Autovac is in the millimeter range.

Other features include a wide measuring range, connection for 4 gauge tubes, and an ability to actuate an external relay circuit. (201)

• • •

A NEW POLYMER, identified as Silastic 430 Gum, and a reinforced gum, or master batch called Silastic 432 base are being manufactured by **Dow Corning Corporation.**

Silastic 430 makes it possible to compound silicone rubbers which in some cases may be molded in conventional organic rubber molds. It is designed to shrink a minimum during vulcanization. Parts that have extremely high resistance to compression set can be made without toxic additives and a relatively short cure using Silastic 430.

Silicone 432 Base, consisting of 80% polymer and 20% Dow Corning Silica is easily and rapidly blended with additional fillers or extenders.

Because of its inherent low shrink and low compression, the need for toxic additives is elimiated. Compounding with properly selected fillers results in finished silicone rubbers with excellent physical and dielectric properties. (202)

• • •

A RAPID-START fluorescent lamp ballast approximately one third lighter than previous models of a similar design is being marketed by **Canadian General Electric Company.**

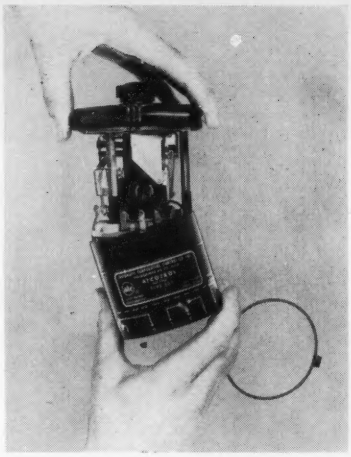
The ballast incorporates a new core shape which achieves the required impedance with less wire and core material. This results in a 28 per cent smaller cross-section and a weight reduction of nearly two lb.

Considerable savings in installation and shipping are effected by the weight-size reduction.

A high power factor model designed for use with two 40-watt rapid start fluorescent lamps, the new ballast is sound rated B for use in classroom, churches and quiet office installation. It has a circuit voltage of 110-125 volts, a minimum line power factor of 90 per cent, and line current of .85 amps. (203)

• • •

A PRIME requirement of industrial controls for automation is their compact design, so that they occupy minimum space. With this trend toward miniturization, the **Automatic Temperature Control Co.** has developed a cylindrically shaped chassis body for the new Atcotrol timer that is mounted in a three and three sixteenth in. diameter cut out. The design of the timer gives a compact protective housing for the chassis, which contains the electric timer's working parts.



Another automation device

The need for compactness has resulted in the use of a close-fitting, one-piece tube which slips directly over the chassis body. At the front end of the timer, the housing seats firmly against a cellular neoprene gasket; at the rear, a neoprene O-ring fits in a groove to hold the tube securely in place, completing the dust-proof, moisture-resistant seal.

Since the housing has to be in direct contact with the metal of the chassis body and, in panel mounted installation, in contact with the panel itself, the housing material has good insulating properties.

The timer has a dielectric strength of 500 volts per mil for a ⅛ in. thickness, perpendicular to the laminations.

For heavy industrial use the housing has high impact strength, resistance to heat, and is impervious to most gases. The timer's external wiring diagram is silk screen printed on the housing.(204)

• • •

A STATIC pressure indicator-controller, designed to control at a pressure range as low as 0 to 0.2 inches of water is being marketed by **Johnson Temperature Regulating Company of Canada, Ltd.**

The new controller can be used for pressures above or below atmospheric, or for maintaining a constant differential between two pressures. Calibrated dials for pressure ranges of 0 to 0.2, 0.3, 0.4, 0.5, 1.0, 2.0, 4.0, 6.0 inches of water are available on all instruments. (205)

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New Products

(Continued)

A NEW INSTRUMENT, especially designed to detect and measure potentially hazardous atomic radiation in industry, is being offered by the **Curtiss-Wright Corporation, Electronics Division.** It is being demonstrated at the Atomic Exposition in Cleveland's Public Auditorium.

The unit, called a Radiameter, weighs only 2 lb., fits into a suitcoat pocket, and

Curtiss-Wright's Radiameter

is operated by an ordinary flashlight battery.

The Radiameter has been designed according to the requirements of the health physicist, an entirely new class of scientist who sees to it that nuclear and x-radiation is used safely. The problem is that radiation acts insidiously; it is not detected by any of the five senses, and damage is often not detected until years later. If used as prescribed by the AEC and various state agencies, radiation is harmless.

This instrument provides a reliable means of periodically monitoring installations and X-ray machines to assure safety of personnel. The unit is so simply designed that it is possible for plant personnel to make checks with minimum supervision from the health physicist or industrial hygienist. (206)

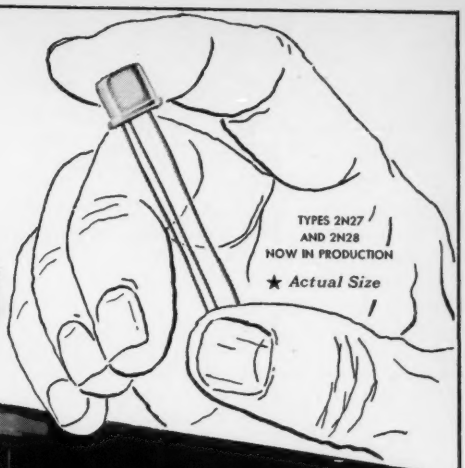
• • •

A NEW LINE of 6-in. stroke Nonuplex Direct Flow pumps for heavy duty pumping application has been offered by the Aldrich Pump Company.

These 9-plunger reciprocating pumps offer advantages of positive displacement, high-speed operation, compact construc-

(Continued on page 62)

Junction Transistors



Skill is required to operate complicated equipment installed in our Montreal Plant to produce grown NPN crystals for Junction Transistors.

"Single crystal" of pure germanium grown in our plant for use in Junction Transistors.

Based on Fundamental research in semi-conductors, Northern Electric now offers "Home Grown" NPN Junction Transistors.

Grown Junction Transistors have Superior characteristics especially for low power operation and compare favourably in respect to "Noise" with the best vacuum tubes. They are ideal for low level Transmission Amplifiers.

- ★ *Manufactured To Close Tolerances*
- ★ *Alpha Closely Approaching Unity*
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- ★ *Non-microphonic*
- ★ *Light Weight*
- ★ *Small Size*

Northern Electric
COMPANY LIMITED
44 BRANCHES THROUGHOUT CANADA

2054-1

New Products

(Continued from page 60)

tion, interchangeability of parts, low maintenance and minimum discharge variation. (207)

• • •

Rated at 900 bhp, the Nonuplex pumps operate at speeds up to 300 rpm and have pumping capacities up to 1,520 gpm, or 52,200 bbl per day. They are available with six different interchangeable fluid ends and 20 different plunger diameters. Plunger diameters range from 2 in. to 5¼ in. in increments of either ⅛ or ¼ in. Changes in speed and plunger sizes permit a wide range of pumping capacities, giving any desired intermediate throughput.

These pumps are suitable for drive by engine or synchronous engine-type motor. The crankshaft is located near the floor, which eliminates the need for expensive foundations to raise the driver or the need to lower the pump below floor level. Nonuplex pumps feature Direct Flow fluid ends and inverted design for compactness and ease of maintenance.

Its design reduces to a minimum the discharge flow variation (pulsation) normally associated with reciprocating pumps. Total variation is only 2.2% (variation above mean—0.7%, variation below mean—1.5%).

All wearing parts in the 6-in. stroke series are interchangeable between Triplex (3 plungers), Quintuplex (5 plungers), Septuplex (7 plungers) or Nonuplex (9 plungers), except crankshaft.

These pumps have wide application in the metalworking, plastic fabricating, chemical processing and petroleum industries. They are used in heavy duty forging press service, die casting and extrusion, heavy duty rubber and plastic molding, large volume chemical handling, oil field water flooding, pipeline pumping and in centralized hydraulic systems. (208)

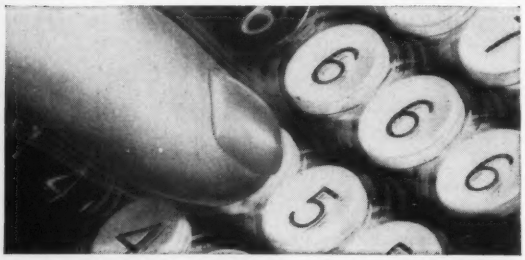
• • •

AIRBORNE WEATHER Radar, installed in the planes of major airlines is being used to detect storm areas and enable flight through the storms. To meet commercial airline requirements for radar installation test equipment, The Narda Corporation is now producing the Model 833 Echo Box. This device is a high Q resonant cavity, specifically designed for rapid testing of the over-all performance of C-Band (5350-5450 mcs) Airborne Weather Radars.

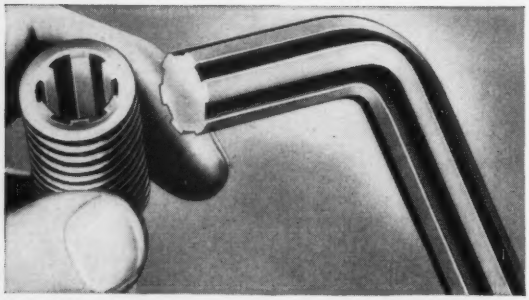
The Narda 833 Echo Box is enclosed in an aluminum box measuring 7 in. x 10 in. x 14 in. The cavity is coupled to the radar transmission line through a directional coupler or with a pickup antenna placed near the radar antenna.

During the radar transmitted pulse, microwave energy is stored in the echo box. Immediately following the pulse, the energy is returned to the radar over the same path producing a signal or target on the radar indicator. At the end of the pulse the returned energy decays exponentially, finally disappearing into the background noise clutter at a point determined by the receiver sensitivity and transmitter power output. Therefore, the time interval between the beginning of the transmitted pulse and the point where the signal on the radar indicator disappears into the noise (called the "ring time") measures the over-all performance of the radar.

The Narda 833 Echo Box is used to determine over-all radar performance, to facilitate tuning adjustments, and to obtain an approximate spectrum analysis. (209)



Vibration won't loosen the set



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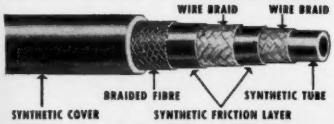
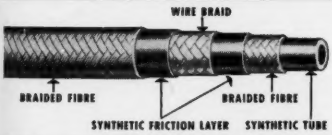
SYNTHETIC COVER



HIGH PRESSURE
DOUBLE WIRE BRAID
SYNTHETIC COVER



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IMPREGNATED BRAIDED FIBRE

MEDIUM HIGH PRESSURE
SINGLE WIRE BRAID
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File

New booklets and books written for you

A NEW bulletin entitled "Engineering Materials To Improve The Design And Performance of Your Product" is announced by **National Fibre Company of Canada, Ltd.**

This 2-color folder describes and illustrates the physical properties and use benefits of the company's two basic engineering materials—vulcanized fibre, a converted cotton cellulose and laminated plastic, a family of thermosetting high pressure laminates.

Photographs and drawings illustrate a few of the many industrial uses of these materials: noiseless gears, thrust washers, cams, terminal blocks, armature slot insulation, shock plates in gun mounts, printed circuits, abrasive wheels, textile bobbins, waste baskets, fuel pumps, carburetors, propeller pitch controls, athletic equipment, luggage, and material handling receptacles. Tables list fibre and Phenolite grades, specifiications, characteristics and applications.

The bulletin also describes the company's design and fabricating service—set up to help companies with their design problems and to provide facilities and experienced personnel for fabricating vulcanized fibre and laminated plastic. (210)

• • •

COMPLETE engineering details on the assembly procedure for Cone-Drive double-enveloping worm gearing are contained in a new bulletin from Cone-Drive Gears, a division of **Michigan Tool Co.** The bulletin covers the latest methods of assembly using taper roller bearings, which are not standard equipment on both worm and gear shafts.

Concise, easy-to-read text is illustrated with engineering drawings and sketches. Color is superimposed on sketches to illustrate typical alignment conditions that result when the worm is blued and meshed with the gear. Instructions for correcting misalignment are included. (211)

• • •

A NEW two-page bulletin describing the new Series S22 power steering booster for smaller vehicles is available from **Vickers Incorporated.**

The bulletin discusses the design, construction and maintenance features of the new booster and includes application and ordering information. Recommended pump and reservoir equipment for use with the S22 booster are also described and typical steering pump performance curves are included.

Two typical circuit diagrams are presented. One shows a conventional steering circuit using a pump having an integral oil reservoir; the other is a drawing of an alternate circuit for use where space limitations preclude installation of the integral oil reservoir. (212)

• • •

THE DESIGN, construction, installation and operation of the A-S-H Hydro-Ejector is covered in a new bulletin, available from The **Allen-Sherman Hoff Co.**

Photographs, line drawings and cutaway views in this 4-page bulletin illustrate the application of this unit to hydraulic materials handling systems. The Hydro-Ejector is a jet pump designed to pump a mixture of solids (such as boiler bottom ash or iron pyrites rejected by coal pulverizers) and water through a transporting pipeline.

A table of "Capacities and Related Data"—the first of its kind ever published—lists the following: the four Hydro-Ejector sizes available; output capacities in either ft. per sec., gpm, per cent of solids, or tons of solids per hour; the jet water head at the nozzle tip for various pressure ranges (measured in psig); transport pipe diameters (in inches); the pipe friction head (ft per 100 ft); and other related specifications. (213)

• • •

A BULLETIN covering a new line of high-temperature Crystalite refractories that permit improvements in operating life as high as 250 per cent in comparison with competing brands of mullite is available from **Richard C. Remmey Son Co.**

This 12-page bulletin describes how improved processing techniques give the new refractory the following advantages: superior refractory qualities up to and including 3326 F (1830 C), very high resistance to thermal spalling, highest resistance to structural spalling, and highest resistance to deformation at high temperatures.

Tables list the physical and chemical properties of Crystalite grog. Crystalite refractory (a superior general-purpose mullite), and Crystalite A refractory (a special high-temperature, high-strength refractory).

Photographs illustrate Crystalite bricks and special shapes, thermal spalling comparison tests, and the seven mesh sizes available; minus 2, plus 4; minus 4, plus 6; minus 6, plus 10; minus 10, plus 20; minus 20, plus 60; minus 60, and collector fines.

Bulletin also contains a thermal conductivity chart and case history installations covering typical uses in glass furnaces, ceramic kilns, basic steel processing, non-ferrous foundries and power plants. (214)

• • •

Book Department

Basic Mathematics

THE AIM OF Basic Mathematics, for Science and Engineering, by Andres, Miser and Reingold, is to present the mathematics required for an intelligent pursuit of elementary science and engineering courses and to serve as a preparation for a course in the calculus.

In this the book is most successful, mainly because there are plenty of worked examples of a practical nature.

Choosing sections at random from the 846 pages, there is a very useful hint on page 22 of how a large number, like 93 million, can be written as 9.3×10^7.

Pages 70 to 73 deal with applications of algebraic equations to scientific and engineering formulas and is good, but on page 147 it might have been a good plan to mention the mnemonic "allsintancos." It is so helpful for remembering the quadrant in which the trigonometric ratio is positive.

Also, on page 492 the rule for a quadratic equation is often easier to remember when stated in so many words; "add half the coefficient of x, all squared."

A slightly more practical example, dealing with a simple space framework, might have been given on page 632, to show the tabulation that the practical engineer would use for direction cosines.

The Appendix, starting on page 736, is most useful. It was a good idea to include the Greek alphabet, the prefixes used and the units of length, mass and so on. However, there doesn't seem to be much point in quoting the value of π more accurately than 3.14159 (on page 772).

The book is very well produced except for the line work in some of the diagrams, of which figure 5.19 is about the worst.

John Wiley & Sons publish the book at $6.75.

MISSING PAGES 65-66, READER SERVICE CARD

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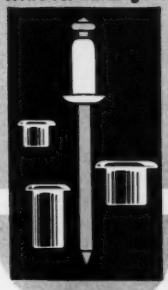
"POP" Rivets handle blind spots and open sections—can be driven at rate of 1200 per hour.

Write for catalogues.



USMC

UNITED SHOE MACHINERY COMPANY

OF CANADA LIMITED

MONTREAL • TORONTO • GALT • QUEBEC

FLEXIBLE, UNBREAKABLE *Polyethylene* TERMINAL BLOCKS

UNMATCHED VERSATILITY!

Lightweight Polyethylene Terminal Blocks are unbreakable!

They will not crack or chip. They are weather-proof — rust, rot and mildew-proof. Oil and gasoline cannot harm them.

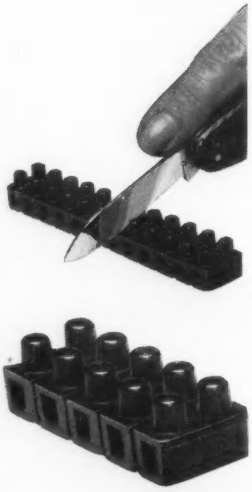
Also, these new 12-post terminal blocks are specially moulded to give big extras in convenience.

Any number of posts can be cut from the block with a pocket-knife — quickly and easily. There are installation bolt-holes between each section. This eliminates detailed pre-job planning — no need to specify the number of posts required in each block. Every one is made to order — right on the job!

Rust-proof brass binding screws are held in deeply moulded cups. Screws cannot accidentally fall out during wiring operations.

Polyethylene Terminal Blocks — unmatched for strength and resilience!

Dielectric Strength — 2.5 KV/mil.
Voltage Rating — 500 volts.



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Letters

Readers' viewpoints . . .

● It seems like only yesterday that we first talked of an article on photoelasticity for DESIGN ENGINEERING. Now that it has appeared, I cannot help but feel some pride for our joint effort . . .

No doubt there will be some criticisms of the article—and I would like to be among the first to make them.

1. "Treatise on Photoelasticity" was written by Coker and Filon and not by Dohen as I erroneously stated in the manuscript.

2. In figure 3a, the outer fringe orders reading from 9 o'clock to 12 o'clock should be 4.5, 4, 2, 0, 2, 4, 6. In figure 3b, a very important fringe order is omitted at inner 3 o'clock; it should be 7.5.

3. I was somewhat disconcerted by the re-writing that had been done—not so much by the actual changes and additions that you made as by the fact that I was not given an opportunity to see the alterations before publication. Any lack of clarity or correctness will be charged to me.

While the number of manuscript alterations was not great, I would have debated some of them . . .

I. W. SMITH,
Assoc. Prof. of
Toronto *Mechanical Engineering*

● I found your article on photoelasticity (DESIGN ENGINEERING, December issue) extremely interesting. This is an important subject today and you handled it well. I notice that you credited "Treatise on Photoelasticity" to Dohen which is not correct. It was by Coker and Filon.

The December magazine was the best one yet, in my opinion. Best wishes for more like it in 1956.

C. H. FRUME,
Montreal *Product Designer*

● I would like to compliment you on the way in which you presented the article on Miss Supertest and on the graphic sketches that your art department drew . . . The article should give . . . a good picture of what is involved in high powered, high speed boating.

We have made some changes in the boat which we feel should improve her performance for the coming year and have only just concluded our trials for this year.

JAMES G. THOMPSON,
Assistant Secretary,
London *Supertest Corporation*

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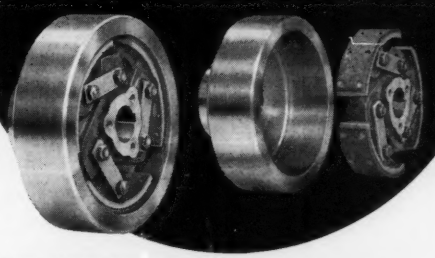
Flexible
ACTION IN THE
New HILLIARD
TWIFLEX
AUTOMATIC CENTRIFUGAL CLUTCH COUPLING



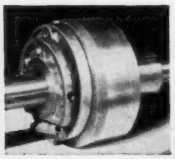
11 NEW IMPORTANT FEATURES . .

1. Flexible in all directions.
2. Absorbs Shock.
3. Limits torsional vibration.
4. Has adjustable idle speed
5. Can be furnished in automatic free-wheeling type.
6. Smooth starting.
7. No slip under normal load at full speed.
8. Protects driver and driven mechanisms against overload shock.
9. Can be furnished in automatic backstop type.
10. Prevents torsional resonance.
11. Easily assembled even in blind installations.

If you have problems of misalignment - smooth starting - vibration - overload - or assembly in the manufacture or operation of:

- Compressors
- Blowers
- Diesel Engines
- Excavators
- Refrigeration
- Hammer Mills
- Textile Machinery
- Wire Machines
- Fans
- Gasoline Engines
- Back Stop Brakes
- Mixers
- Conveyors
- Pumps
- Electric Motors
- Generators
- High Speed Pulverizers
- Tube Mills

• Let Our Engineers Consider Your Problem. Twiflex May Be The Answer.



OVER-RUNNING CLUTCH

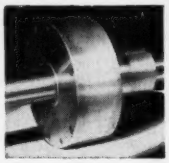
For automatic engagement and release on two speed drives, dual drives and for ratchet feed or backstop action.

Write for Bulletin 231.

SLIP CLUTCH

For overload protection — constant torque — constant tension on reeling or winding stands.

Write for Bulletin 300.



SINGLE REVOLUTION CLUTCH

For automatic, accurate control, electrically or mechanically, of intermittent motion, indexing, cycling, cut-off.

Write for Bulletin 239.

WRITE TODAY!

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MANUFACTURING CLUTCHES FOR 50 YEARS

Editorial

A Wonderful Year of Progress is Lying Ahead

SO NINETEEN-FIFTY-SIX is with us — and DESIGN ENGINEERING wishes all readers a fine year of progress. Looking ahead from the last days of 1955, as this editorial goes to press, it is already possible to see many exciting challenges that may be met before the new year is an old one. If everything goes as well as it might, engineers in our industries will have good cause to rate 1956 a "happy"—and an encouraging—year.

Of course, it is easy to send wishes. But the magazine plans to do much more than this; it plans to assist readers toward improved knowledge, higher status and better times. A long program of feature material, carefully chosen for Canadian engineers, has already been drawn up for the year ahead. Here is a preview of some of it:

Much has been written about turbine engines for aircraft; but what do you know about the latest automobile turbines? The gas turbine car might well be with us before the new year is out. Big, new steps forward have been taken in this complex piece of engineering design. So, DESIGN ENGINEERING will be putting all the facts of auto turbines before you in an early issue.

Nor is the turbine the only threat facing today's idea of the family automobile. Fuel injection is also coming—for the first time ever on a mass-produced scale. How is it done and what does it mean? A coming issue of DESIGN ENGINEERING will tell you!

Other "component" news will include expert accounts of precision casting by lost wax, frozen mercury and shell molding processes. And there will be a report on brittle coatings, a modern method for spotlighting highly stressed component parts.

Among many features that will keep Canada's engineers up to date on materials trends will be a review of glass and its uses. This material has been a servant of man for 5,000 years, yet is always offering something new. Over 14 billion tons of glass were manufactured into $1.6 billions worth of products in 1954! Many of these products show new ways of thinking about glass, still a "wonder" material despite its old and honorable age.

Steel news, too, is on the way; two up-to-the-minute steel articles are already listed. One of them discusses modern oxygen steel processes, which have come forward in recent times to demand the attention of progressive engineers. And stainless steel, an older material with countless new uses, is also scheduled. A tabulation of types and uses for handy reference will run with this feature.

Ceramics no longer belong to the potter alone. Because of their resistance to chemical and temperature changes, ceramics have become a subject—and an important one—for the engineer. Space has been reserved for it in a coming issue.

Then there are many thing that DESIGN ENGINEERING has to say about finishes. Among them will be electrostatic spraying, bonderite processing and flame plating. Study of these and other finishes to be covered will keep readers in touch with fast-improving industrial techniques.

The editors hope that in this way they can help readers make the best of 1956.

Report on a POWER-FULL decade

The first 10 years of jet progress in Canada is marked this month . . . a decade in Canadian creative engineering progress of high significance . . . lifting Canada to a position of eminence in the supersonic era in aviation now upon us.

45 December 2—The Jet Age in Canada gets underway with formation of A. V. Roe Canada Limited.

46 September—Design starts on the Orenda concept of jet power.

49 February—First test run of Orenda 1—5,800 lbs. thrust.

50 October—Orenda earns its wings—first flight in a service aircraft North American F86A. Over 400 contractors and suppliers recruited to provide Orenda parts and accessories.

51 June—Orendas make first flight in Avro CF-100. Development underway on new models—more power, less weight.

1952 September—Orenda's production plant opens . . . the assembly line rolls. Power increased in Orenda 8 at 6,355 lbs.

1953 January—Orenda 10 replaces an American engine in Canadair Sabres.

1954 March—Yet more power—over 7,000 lbs.—in two-stag turbine Orenda 11 (CF-100) and Orenda 14 (Sabre 6). Both now outstanding power performers in their respective classes.

1955 December—Current Orendas deliver some 25% more power than first Orenda for 10% less weight. Close to 3,000 Orendas in six production models now in operation throughout the free world.

and for tomorrow... Under intensive development for the supersonic era, new designs with power far in excess of any current production model.

ORENDA *ENGINES LIMITED*

MALTON, CANADA

MEMBER; A. V. ROE CANADA LIMITED & THE HAWKER SIDDELEY GROUP

1956

How high load capacity is built into less space in Dodge-TIMKEN All-Steel pillow block

THIS rugged Dodge-Timken pillow block packs more capacity in less space than ever before. All-steel construction gives it extra strength and durability. The design is compact. No special thrust devices that take up extra space are needed—the two-row Timken tapered roller bearing takes *both* radial and thrust loads in any combination. And full line contact between the rollers and races assures high load capacity.

The cutaway view below shows the bearing. It is of special design, with tapered bore and self-aligning spherical outer surface—never requires adjustment. As in all Timken bearings, races and rollers are case-carburized and have tough, shock-resistant cores under hard, wear-resistant surfaces. Under normal conditions, the Timken bearing will last the life of the machinery with which the pillow block is used.

In addition to the all-steel pillow block shown here, Timken bearings are also used in the Type "E", Double-Interlock, Type "C", and Special-Duty pillow blocks—other versatile pillow blocks in the Dodge-Timken line with a wide variety of uses in industry.

To be sure of the finest bearing steel, we make our own. No other bearings can give you all the advantages you get with Timken bearings. Include them in your design plans . . . specify them for the machines you buy or build. Look for the trade-mark "Timken"—it's on the bearing that makes any machine run better. The Timken Roller Bearing Company, Canton 6, Ohio, U.S.A. **CANADIAN PLANT:** St. Thomas, Ontario. Cable: "TIMROSCO".

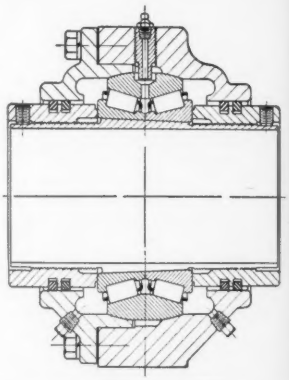
This symbol on a product means its bearings are the best.

TIMKEN *Made in* **CANADA**

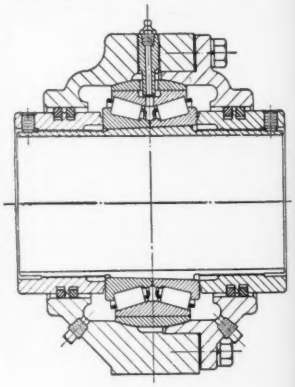
TRADE-MARK REG IN CANADA AND U.S.PAT OFF

TAPERED ROLLER BEARINGS

FOR CANADIAN INDUSTRY



How **DODGE MANUFACTURING CORPORATION,** Mishawaka, Ind., U.S.A., mounts Timken bearings in the Dodge-Timken All-Steel pillow block. Above: non-expansion block with fixed bearing. Below: expansion block with floating bearing.



NOT JUST A BALL ○ NOT JUST A ROLLER ⊂⊃ THE TIMKEN TAPERED ROLLER ⊂⊃ BEARING TAKES RADIAL ◐ AND THRUST —◐— LOADS OR ANY COMBINATION

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